AGRICULTURAL SOCIETY OF NIGERIA (ASN)

LANDMARK 2022

PROCEEDINGS

56th Annual Conference

THEME:

"ATTAINING SUSTAINABLE FOOD SECURITY AND AGRICULTURAL DEVELOPMENT AMIDST CLIMATE CHANGE, COVID-19 PANDEMIC AND GENERAL INSECURITY IN NIGERIA."

24th - 28th October, 2022

LANDMARK UNIVERSITY, OMU-ARAN, KWARA STATE.

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Sub-Theme D:

Biosafety issues in agriculture, Smart agriculture and climate changes, Agriculture engineering and mechanization strategies

PRESIDENTIAL ADDRESS OF THE AGRICULTURAL SOCIETY OF NIGERIA (ASN), BY DR. MOHAMMED NDAGI ISHAQ ON THE OCCASION OF THE OPENING CEREMONY OF THE 56th ANNUAL CONFERENCE OF THE SOCIETY AT THE CONFERENCE HALL OF LANDMARRK UNIVERSITY, OMUARAN.

His Excellency, The Executive Governor of Kwara State.
The Chancellor, Landmark University; Dr. David Oyedepo
The Vice Chancellor, Landmark University; Prof. Charity Aremu
Distinguished Keynote and Plenary Speakers
The Executive Director, National Cereals Research Institute, Badeggi
The Executive Director, National Root Crops Research Institute, Umudike
Presidents and Officers of Sister Societies in Agricultural Disciplines
Past Presidents and Fellows of Agricultural Society of Nigeria
Royal Fathers and other titled Men
Invited Guests
Members of the Press Corps
Ladies and Gentlemen

It gives me great Pleasure to honorably welcome you all to the 56th annual conference of our great society as I end my tenure as the President. It is my heart felt pleasure to welcome you to this annual event of the Society. I want to specifically welcome the Proprietor of this University, Dr. David Oyedepo who saw the light in Knowledge seeking and took a great stride to establish this beautiful fountain of knowledge. Landmark University is one of fastest growing University in Nigeria today. I am enormously delighted to welcome the Keynote Speaker, Mr. Leye Alayande, MD/CEO Hybrid Feed Ltd, the Lead Speaker Prof. Babalola, Research Director, North West University South Africa.
I extend a big welcome to our host, the Vice Chancellor, Professor Charity Aremu for the acceptance to host us and the much efforts she put in having a befitting conference despite numerous challenges. ASN is highly appreciative of the entire management staff and particularly the Local Organizing Committee who have been working tired less despite ASUU strike in other Universities.

AGRICULTURAL SOCIETY OF NIGERIA IN SYNOPSIS

The Agricultural Society of Nigeria (ASN) started as far back in 1962 at the Faculty of Agriculture, University of Ibadan. The society was started by a group of concerned Agricultural Professionals who graduated in various fields of Agriculture, Forestry and Veterinary Medicine, as well as those who had their Diploma Certificates in General Agriculture and Agricultural Engineering from Nigeria and abroad. The society was born out of patriotism to assist our nation, Nigeria, to regulate the practice of agriculture in all its fields, which includes plant breeding and genetics, soil science, animal husbandry, agronomy, forestry, plant protection, fishery, veterinary medicine, etc. The Society no doubt has come of age as it was formally registered with CAC and have made substantial progress in the bid to register Agriculture as a professional body in Nigeria.

THEME OF THE 56th ANNUAL CONFERENCE

The anchor theme of this year's Annual Conference is “Attaining sustainable food security and Agricultural Development Amidst Climate Change, COVID19 Pandemic and General Insecurity in Nigeria”. This caption, you would agree with has come in no better time than now that the Federal Government is making frantic efforts in sustaining food production despite the numerous challenges especially security issues. The keynote and plenary speakers are well experienced experts in the agrarian business both locally and internationally with requisite wealth of practical experiences to deal decisively on topics bothering on the theme and the sub-themes with the aim of addressing critical issues that has become the blight of agricultural development in Nigeria today. However, Careful implementation of suggested solutions no doubt will go a long way in making our country not only self-sufficient in food but will also, provide means of livelihood to the teeming unemployed youth population and provision of better security for farmers in particular and Nigeria as a whole.

THE NIGERIAN INSTITUTE OF AGRICULTURISTS(NIAg)

The engine of efforts has continued to steam and there is no going back towards registration of Agriculture as a professional body in Nigeria. Much success has been recorded and presently our bill is still waiting for Presidential accent. We are hopeful the Institute will soon be established. This is a joint effort by the Agricultural Society of Nigeria (ASN), Association of Deans of Faculties of Agriculture (ADAN) of Nigerian Universities to establish the Nigeria Institute of Agriculturists (NIAg) as a professional body. This is borne on the premise that registration of Agriculture as a profession in Nigeria will reposition Agriculture to play its leading role as a major driver of our economy. It is known that all disciplines in agriculture, which are interdependent cannot stand alone but MUST come under one multidisciplinary professional body and work in synergy for effective service delivery and for ease of governance. Our graduate agriculturist will also have a better consideration and placement on high grades like their counter parts in engineering, medicine. Surveyors etc. We there seek your support toward realization of this dream. NIAg will ultimately serve the same purpose just like COREN is to Engineers and NMA is to medical doctors with their affiliate bodies.

PROGRESS MADE BY THE SOCIETY

It is with deep sense of commitment that I wish to state some of the other progress the society has made these past few years. The Society owns and maintains a website: www.agriculturalsocietynigeria.com www.facebook.com/agricsocietynigeria10000 likes and followers. The society has a landed property within the premises of University of Abuja and we are poised to developing the property. The Institute building will definitely be sited there.

PUBLICATIONS OF AGRICULTURAL SOCIETY OF NIGERIA

The Society maintains and sustains regular Journal publication. The Journal of the Society contains information on new technologies and inventions in the field of Agriculture which is of high standard and highly subscribed by scientists all over the world. The 2022 edition of the Journal is available for purchase at moderate price. A copy of recent publication will also be included in your conference bag. Our journal is highly patronized worldwide as we had call, for purchase of past and present editions from outside the country. The Society also publishes book of Proceedings of the current conference which is a compilation of the papers to be presented during the conference. The current and old volumes are available when you visit our website. We also publish a quarterly Newsletter to give updates on the activities of the Society and state of agriculture in the country. Limited hard copies of this year's proceedings are available for sale on a first-come-first-served basis while the electronic copy is part of registration package.

MEMBERSHIP DRIVE AND CERTIFICATES

Membership of the society continues to grow. Presently we have over 3,000 members cutting across the various disciplines in agriculture. This was made possible through our redesigned website that facilitated online registration and payment. Membership certificates are dispatched in record time and this is renewable every year as soon as members pay their annual dues except for Life members.

FELLOWSHIP AWARDS

In the course of this conference 3 distinguished Nigerians will be inducted as Fellows and some others will be given award of excellence for their various contributions to the development of agriculture in Nigeria. The Chairman of the Award Committee will invite the recipients to the podium at the appropriate time.

CONCLUSION

I want to express my delight and gratitude e to the present executive council of ASN for supporting me throughout my tenure which ends tomorrow. In particular the elders among us, Prof Omeje, Prof. Onwuka and late sir Akinniyi (may we rise and observe a minute silent for him). He was among the founding fathers of the society and contributed immensely to the success of NIAg. The Proprietor of the University, Our Guests of Honor, Distinguished Guests, Ladies and Gentlemen, I wish to thank you and all for finding time to grace this occasion despite numerous challenges. Undiluted thanks go to our Host, The Vice chancellor of the University, for making this Conference a memorable one.
Please Remember to enjoy the ambience environment of Landmark University and Omu Aran town.

Thank you and God Bless You all.

Mohammed Ndagi Ishaq, PhD
President–ASN.

PROCEEDINGS

56th Annual Conference
Agricultural Society of Nigeria
24 - 28 Oct., 2022

SUB-THEME: A

Optimizing Agricultural Business and Food Security Amidst Rising General Insecurity in Nigeria

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PROCEEDINGS
56th Annual Conference
Agricultural Society of Nigeria
24 - 28 Oct., 2022

ABSTRACT

Nigeria has been named one of the terrorist countries of the world. Many lives and properties have been lost and a large number of citizens rendered homeless due to the activities of Boko Haram insurgents, Fulani herdsmen and associated terrorists. While millions of farmers have been displaced from their ancestral farming communities, others are perpetually afraid for their lives and as such cannot optimally engage in farming activities. The direct implication is declining farm productivity with attendant food insecurity. Government had made frantic efforts to tackle these challenges posed by terrorism and insecurity in the country and put an end to it but the rate of insurgency and insecurity is still alarming. This paper is a review of existing literature on impact of rising general insecurity on agricultural business and food security in Nigeria. Findings have shown that the escalation of security situation in parts of the country has caused many farmers to abandon their farms. Thus, it is strongly recommended that Nigeria should seek adequate assistance from international communities in order to overcome terrorism in the country. Besides, government should support the call for ban on open grazing by the Southern state governors to curtail farmer-Fulani herdsmen conflict so as to foster the sustainability of a peaceful atmosphere where agricultural business, farm production and related socio-economic activities can thrive.
Key words: Agricultural Business, Terrorism, Insecurity, Food Security, Optimization

INTRODUCTION

Food security is a priority in every country, being a key driver for human survival and socio-economic development. Unfortunately, food insecurity is prevalent in Nigeria despite its favorable agro-ecological endowments. Food security has become a national priority for the country considering that a vast majority of its 198.1 million population is food insecure (FMARD, 2016). A household is considered food secure when its occupants do not live in hunger or fear of starvation (FAO, 2019). According to World Bank (2010), food security is of three folds, these are food availability, food accessibility and food affordability. Food availability for farming households means ensuring sufficient food for the households through production. A reduced production can lead to a decline in food availability which can cause a reduction in market access to buyers. Hence, food security connotes physical and economic access to adequate food for all household members, without undue risk of losing the access (Agaptus, John, & Modupe, 2019). Household food security issues cannot be seen in isolation from broader factors such as physical, policy and social environment. According to FAO (2019), between 2016 and 2018, the total number of undernourished Nigerians was 9.1 million but Nigeria's food and nutrition insecurity remains a worsening trend. Thus, this study underscores the impediment that rising general insecurity poses to the realization of sustainable agricultural business and food security in Nigeria.

METHODOLOGY

This is a review paper and its research methodology was based on review of existing literature

RESULTS AND DISCUSSION

Concept of Insecurity

Insecurity as a general term refers to a state of being subjected to fear, threat, danger, molestation, intimidation, harassment and its likes in all aspects. It is a situation of fear or anything that causes fear, harm, or has the capability to cause fear, harm, injury, destructions to an individual, group or nation. The concept of insecurity connotes different meanings such as: absence of safety; danger; hazard; uncertainty; lack of protection, and lack of safety. Beland (2015) defines insecurity as a state of fear or anxiety due to absence or lack of protection. Achumba, Ighomereho, and Akpor-Robaro (2013) also defined insecurity from two perspectives. Firstly, insecurity is the state of being open or subject to danger or threat of danger, where danger is the condition of being susceptible to harm or injury. Secondly insecurity is the state of being exposed to risk or anxiety, where anxiety is a vague unpleasant emotion that is experienced in anticipation of some misfortune. For the purpose of this study, insecurity is conceived as a situation where human and national security of a state is compromised by internal or external forces or interests exacerbated by the former's weak or poor economic, military and/or human resource development conditions.

Since the birth of Boko Haram in Nigeria in 2008, the country has witnessed an unprecedented level of insecurity. Banditry, kidnapping, farmers/herdsmen conflict, attacks by IPOB/ESN and other violent crimes have become the order of the day. No geopolitical zone has been spared by the vicious scourge of conflict though their prevalence and intensity have not been the same in occurrences across the length and breadth of the nation. The present situation is further intensified by elements of globalization, natural disasters, proliferation of weapons and light arms, corruption, executive lawlessness and leadership ineptitude (Chinwokwu, 2012).

The escalation of security situation in parts of the country has caused many farmers to abandon their farms. This is as a result of fear of attacks especially by marauding Boko Haram insurgents, clashes between herdsmen and the farmers, communal conflicts and other forms of conflicts. Northeast Nigeria has been struggling with the Islamist insurgency since 2008.

Violent conflict has severely weakened fragile livelihoods resulting in a deep humanitarian crisis. According to Eneja, Babagario, and Agri (2019), the states of Adamawa, Borno and Yobe recorded very high levels of food insecurity over the past decade. In addition to the deadly activities of the Boko Haram sect in the northeastern geopolitical zone of the country, another major threat to national security with serious implications for food security is the menace of Fulani herdsmen. The Fulani herders are mainly nomadic as they traverse the entire country in search of pastures for their herds. The transhumance tradition of the Fulani herders has often pitted them against sedentary farmers as a result of the destruction of the farms of the latter.

In the past, precisely before 1999, these conflicts were well managed by the herders and farmers that they never escalated to the level of recording fatalities. Most crop farmers and those dealing in livestock in the North are fleeing their land en masse and migrating to neighbouring countries because of the crisis. Food insecurity has become a chronic problem. Large-scale population displacement negatively impacted livelihood activities within displaced and host community households. With sustained violence in the northern part of the country and climate change, major cities like Enugu, Port Harcourt, Ibadan and Lagos are getting food price shocks as rising food prices bite into household budgets (MARD, 2016). The FAO (2019) has asserted that conflict-affected countries have on average higher rates of food insecure people than countries not affected by conflict. Violent conflicts can have short term effects on people's nutritional status. This in turn can have long-lasting impacts on their livelihoods.

General and Food Security

National security is all about achieving complete security for both the state and its citizens by engendering an environment of peace. This is paramount because it is only a peaceful environment that catalyzes the realization of people's wellbeing. A peaceful environment must reassure the citizens of their safety from every form of symbolic, physical and psychological threats. The reassurance must be anchored on the demonstrated capacity of the state to guarantee an environment where citizens would be safe to pursue their livelihood activities (Agaptus, et al, 2019). Human security primarily focuses on protecting the integral worth of people against insecurities by dealing with the circumstances that threaten the well-being and survival of the people. Thus, human security emphasizes the establishment of food and water security, economic and political security for the general population as critical mechanisms to achieve a more stable level of state security (Lanicci, Ramsay, & Murray, 2017).

Food security is presumed to exist when all people at all times have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life (FAO, 2019). This situation is practically unrealizable in Nigeria due to the existing national insecurity occasioned by protracted armed conflicts involving sundry groups, especially the Boko Haram group and Fulani herders. The activities of these groups in terms of invasion and sacking of farming communities have resulted in many civilian fatalities, thus creating acute insecurity. The state of insecurity in many of these farming communities has made it practically difficult for farmers to continue to engage in agricultural production optimally, thus affecting productivity and causing market disruptions with attendant food price shocks (Fadare, Akerele, Mavrotas, & Ogunniyi, 2019). The current situation is that Nigeria lacks both the capacity and capability to produce enough food to feed its population despite its favorable agro-ecological conditions.

The productivity challenge is a product of inefficiency arising from continued application of outdated input system and farming models (Esheya, 2019). While making efforts to modernize the agricultural sector, emphasis has also been placed on developing quality crops by revolutionizing seed varieties, fertilizer distribution system, irrigation system and general agronomy practices. At the apex of the checklist of actions necessary to create a conductive environment in which agriculture could thrive is improved security of farming communities to reduce the incidence of criminality (FMARD, 2016).The devastation, which the activities of Boko Haram has caused, is not only obvious but also far-reaching in its impact on agriculture. Besides the Boko Haram group, insecurity in Nigeria has been aggravated by the criminal activities of sundry groups. The group with the most devastating impact is the Fulani herders whose murderous campaigns have targeted farming communities, with no challenge from the state (Amnesty International, 2018). The displacement of farming communities as a result of attacks by armed groups, criminal violence and banditry is associated with the current alarming rise in food insecurity in Nigeria (OECD, 2020).

CONCLUSION AND RECOMMENDATIONS

Rising insecurity has caused serious disruptions in Nigeria's agricultural business activities as it undermines farming capacity and spawns the likelihood of galloping food prices; all of which exacerbate poverty and hunger and signpost a likely nationwide food crisis. The displacement of farmers from their ancestral farming communities by Boko Haram insurgents, Fulani herdsmen, bandits, kidnappers, militants, communal clashes and other associated terrorists has direct negative implication on food security. Many farmers have been forced to abandon their farmlands in search of security and safety, their farm produce destroyed while many of them have been killed. The way out under this circumstance is for government to strategically invest in the security sector by consistently equipping the security personnel with upgraded state of the art security gadgets and as well ensure adequate funding in order to defeat the Boko Haram insurgents and related criminalities; and support the call for ban on open grazing by the Southern state governors to curtail farmer-Fulani herdsmen conflict. This will foster the sustainability of a peaceful atmosphere where agricultural business, farm production and related socio-economic activities can thrive.

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Analysis of Demand for Beef among Households in Oshimili South Local Government Area

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ABSTRACT

The Study was conducted to establish the demand analysis for beef among households in Oshimili South Local Government Are, Asaba, Delta State. 120 respondents were randomly selected for the study and primary data was collected through the use of questionnaire and analyzed by the use of descriptive and inferential statistics shows that: Most respondents were in the age range of 31-40 with a mean age of 45. There was more female respondent than male in the study area. Most respondents had 6-10 persons in their household. Most respondents were highly educated, that is there were more people with tertiary education. The bulk of respondents were into business. Result obtained indicates that most households in the study area demanded 1.1-2.0kg of meat per week. In the regression analysis, findings also showed that the 4 significant variables were income, price of beef, education and household size. All had positive effect on the demand for beef among households except for price which has a negative effect. Recommendations include that Government should subsidize the cost of inputs for cattle production, this will in turn cause a reduction in the price of beef.

Keywords: Analysis Demand, Beef, Household

INTRODUCTION

Agriculture is farming that includes raising of livestock such as ruminants like cattle, goats and sheep and non-ruminants like pigs and poultry. Agricultural economics on the other hand is an applied field of Economics concerned with the application of economic theories in the optimizing of production and distribution of food and fibre. Here, the theory of demand begins with the behavior of consumer, since the market demand is the summation of the individual consumers. Consumption decisions are made by individual or household groups. A consumer is assumed to be rational based on his income and the market prices of various goods and services the consumer plans spending income with the aim of attaining maximum possible utility or satisfaction (Subba *et al.*, 2004). Demand normally means the desire or willingness for a good but in economics, simple desire or willingness for a good alone may not represent demand. Apart from the desire or willingness, consumer should be able to buy the good. Demand is therefore an effective desire. Thus, desire and ability to buy are the key components of demand. It shows the amount of product or service the consumers are willing and able to purchase at each price in a set of possible prices during some specified time in a specified market. (Subba Reddy *et al.*, 2004). According to Eboh (2009) demand means "propensity of the consumers to buy different quantities of a particular good at different unit prices". It indicates how much the consumers would be buying when the price per unit of a commodity is changing (Subba *et al* 2004). The term consumer behavior was defined as the behavior that the consumer displays in searching for purchasing, using, evaluating and disposing of products, service and ideas which they expect would satisfy their needs (Schiffman and Kanuk, 1987). The field of consumer behavior also studies how individual's group and organization select, buy, use and dispose of goods, services, ideas or experience to satisfy their needs and desires (Kotler *et al* 2009). A consumer may feel dissatisfaction with the choice of a particular product or commodity either because he had to forego an equal alternative purchase in order to pay for it or because it has continuing service problem (Schiffman and Kanuk, 1987). Food products of animal origin have played a key role as supplies of human food calories and protein in virtually all parts of the world. Animals are an important source of food, particularly of high quality protein, minerals and vitamins and micro-nutrients. Animal protein contains essential amino acids that are different in cereals. Eating small amount of animal products will correct amino acid deficiencies in cereal based human diets, permitting more of the total protein to be utilized because animal proteins are more digestible and metabolized more efficiently than plant proteins. Furthermore, there is considerable value in diversity of diet for nutritional purposes as well as palatability. Around the world, animal protein is a major source of diversification of calories away from an over reliance on starchy staples (Delgado *et al.*, 1998).

Problem Statement

Animal protein is an essential part of human nutrition because of its biological significance. Tijani *et al* (2006) reaffirmed that animal proteins are more "biologically complete" than the vegetable proteins with regards to their amino acids composition. The dearth in the quantity and quality of protein is a challenge that is beyond dependence on plant protein alone (Tijani *et al 2006)*. It suffices therefore to explore quantity and quality of protein of animal origin of which beef is of prime importance. There is also need to find out the demand for beef by the household compared to the supply.

Objectives of the Study

The main objective of the study is to conduct a demand analysis for beef consumption among farm households in Oshimili South Local Government Are, Delta State, Nigeria. The specific objectives are to: Determine the socio-economic characteristics of household respondents; determine the quantity of beef demanded among households per week; analyze the socio-economic factor affecting the demand of beef and ascertain the factors that determine the demand of meat in the study area.

METHODOLOGY

The study area

The study area is Oshimili South Local Government Area. It covers an area of 268 square kilometres. The local government has tropical climate marked by two distinct seasons; the dry and wet seasons. Oshimili Local Government Area is bounded in the north by Oshimili North Local Government Area in the east by the River Niger, in the south by Ndokwa East Local Government Area. The major town is Asaba with communities such as Umuagu. Ugbomanta, Umuonaje, Umuezei, Umuaji, Anwai, Cable Point, West – End and Bonsac. The villages are Elenchele, Okwe, Powerline, Amakom. Oko – Obiokpu, Oko – Anala, Aniugo, Akpako, Oko – Ogbele and Odifulu. The common occupations in the study area include farming, trading, artisanships, private and public service among others.

Sampling and Sampling Techniques
Multi-stage random sampling technique was used to select sample for the study.The first stage was the selection of villages. 10 villages was randomly selected. Then 12 households were randomly selected from each of the selected villages giving a total of 120 household respondents used for the study.

Data Collection
Data was collected with the use of structured questionnaire administered on 120 respondents usually the head of household or any senior member of the household. There was 100% return rate of the questionnaire. In analyzing the demand of beef, information was collected on the following; the cost of beef in kilos (0.5, 1, ½, 2, etc.) and was gotten from various meat shops. This information is important because it was used in determining the amount consumers spend on these various meat commodities per week, monthly and those who normally demand for it on a rare occasion. Other data gathered include household size, income, sex of head of households and education.

Data Analysis
Data generated was analysed with descriptive statistics of frequencies, percentages and means. t-statistics and regression was also used for analysis.

Model Specification: the multiple regression models were specified and used to analyse the quantity of beef consumed (Y) as function of the selected variables. The explicit form of the mode, the form:

$Y_C – b_0 + b_i X_i + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + N$

Where;

Yc = quantity demanded by the consumer (kg)

Xi = price of beef

X2 = income of the consumer (N)

X3 = taste (Dummy 1 = Yes, 0 = No)

X4 = Household size (number)

X5 = Age of household head (years)

X6 = price of chicken

b_0 = Constant

RESULTS

Socio-economic Characteristics

Age Distribution
Result in table 1 revealed that the age range of 11-20 there was 0.8%, 25.8% were in the age range of 21-30, 37.5% were in the age range of 31-40, 15.83% were in the range of 41-50, 11.6% were in the range of 51-60, 5.83% were in the range of 61-70 and 2.5% were in the range of 71-80. The mean age is 38.92

Table 1: Age Distribution

Age	Frequency	Percentage (%)	
		Mean	
11-20	1	0.8	38.92
21-30	31	25.8	
31-40	45	37.5	
41-50	19	15.83	
51-60	14	11.6	
61-70	7	5.83	
71-80	3	2.5	

TOTAL	120	100.00

Household Size

Result on household size in the study area indicated that 40.8% respondents had a household size of 0-5 persons, 55% had 6-10 persons in their household, and 4.2% had 11-15 persons in their household. The mean household size is 4.62. From the obtained result it is shown that household with more persons will have more demand for beef. FAO (2007) said the overall growth in demand for beef would be much accelerated by the surge in human population, rise in income and urbanization.

Table 2: Household Size

Household Size	Frequency	Percentage (%) Mean	
0-5	49	40.8	4.62
6-10	66	66.55	
11-15	5	5.42	
TOTAL	120	100.00	

Occupation

Table 3 showed that 15.8% respondent were farmers, 6.7% were bankers, 21.6% were civil servants, 3.33% were lecturers, 10% were teachers and 42.5% were business men/women. This implies that most people that demand beef and meat are people who are financially free, they do not depend on a fixed wage and also are self-employed.

Table 3: Occupational Distribution

Jobs	Frequency	Percentage (%)
Farmers	19	15.8
Banker	8	6.7
Civil Servant	26	21.6
Lecturer	4	3.33
Teacher	12	10
Business	51	42.5
TOTAL	120	100.00

Quantity of beef Demanded

Table 4 showed the quantity of beef demanded by household daily in the study area. Results indicated that 34% demanded 0-1.0kg, 43% respondents demanded 1.1-2.0kg, 20% demanded 2.1-3.0kg and 3% respondents demanded 3.1-4.0kg of beef in the study area per day. The result has revealed that a large percentage (38%) of people eat less than a kilogram (kg) of beef per day and thus reduced the nutritional benefit of beef needed by the body and this is in line with Osho and Asghar (2004) who stated that per capital consumption of meat has lagged especially in the less-developed countries of the world. This can be attributed to low income and also high price of beef. Olele (2010) reported that beef demand in most African countries is very low at a level of 2.5kg per day and the demand is even lower especially in the southern and eastern parts of Nigeria where production of animal protein has not been high enough to meet the demands of rapidly growing population.

Table 4: Quantity of Beef Demanded

Quantity of meat demanded (kg)	Frequency N=120	Percentages (%)

0-1.0	41	34
1.1-2.0	51	43
2.1-3.0	24	20
3.1-4.0	4	3
TOTAL	320*	100.00

*Multiple Response Recorded

Demand Analysis for beef in the Study Area

The different socio-economic and other factors could affect the demand of meat in the study area were determined through the use of Ordinary Least Square (OLS) regression analysis. This is in line with the traditional theory of demand. Hence the data generated were fitted into the regression model and tried in different functional forms including linear, semi-log and double log models. The linear model was adopted as the best fit as it has the highest R^2 value as well as highest number of significant variables. The R^2 value of 0.518 implies that about 52% of the changes in the demand for beef were actually caused by the changes in the variables that were entered into the model. It also implies about 48% of the changes in demand were caused by other factors which were not included in the model.

The detail of the variables coefficients standard errors, t-values and level of significance is as presented in the table.

Table 5: Demand Analysis for Beef

Variables	Coefficient	Std error	t-value	Significance
Constant	-535.272	170.408	-3.141	0.003
Sex	-418.062	551.661	-0.758	0.451
Age	489.341	3882.600	0.126	0.900
Marital status	808.095	520.843	1.552	0.077
Household size	421.753	131.367	3.210	0.001***
Education	386.922	197.602	1.958	0.005**
Price	-499.672	130.796	-3.438	0.000***
Income	982.082	155.111	6.332	0.000***

R^2 = 0.518

F-ratio = 7.39

***Significant at 1%, **significant at 5%, *significant at 10%

An F-ratio of 7.39 that the overall regression equation was significant at the 0.001 level of significance.

Table 5 showed that four variables were statistically significant on their effect on demand of meat in the study area. These are household size, level of education, price of the commodity and income.

Household Size: The size of the household with a coefficient of 421.75 and a standard error of 131.37 with a t-value of 32.1 is significant at 1% level. This showed that the more the household of the respondent the more the demand for meat.

Education: Level of education variable had a coefficient of 386.92 and a t-value of 1.96 which is statistically significant at the 0.005 level. This implied that the higher the level of education, the more the demand for beef.

Price of Meat: The price of the beef with a coefficient of -499.67 and t-value of -3.44 is statistically significant at the 0.01 level of significance. The coefficient is also negatively signed. The implication of this is that an increase in the price of beef will lead to a decrease in the demand of the products. This result is in line with the law of demand which states that the higher the price the lower the quantity demanded and the lower the price the higher the quantity demanded (ceteris paribus).

Income of Respondents: The level of income of respondents with coefficient of 982.08 and t-value of 6.33 is statistically significant at the 0.01 level. It is positively signed. This implies that the more the income of the consumer the more they demand meat products all things being equal. The result is also in line with respect to demand of normal goods.

Conclusion

The study showed that beef is an important part of household diet. Although household size is a factor that cannot be overlooked, income is an important determinant on the quantity the household will purchase. The study therefore made the following recommendations:
Government should subsidize the cost of inputs for cattle, this will in turn cause a reduction in the price of beef and poultry meat. Since cattle is not reared in Oshimili South Local Government, there is need for intervention in the area reduction in transport cost and provision of storage facilities. These will help to reduce prices of beef and increase the quantity available to households. Government should provide modern abattoirs for cattle slaughter to ensure quality beef are sold to the consumers. Also consumers of beef should join or form cooperative societies. This will help pool their resources together to purchase the product in bulk and reduce the price and increase the quantity of beef available than when the product is sold at retail prices.

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Marketing Efficiency of Sweet Potato in Owerri Metropolis Imo State, Nigeria amidst Covid-19 Pandemic: A Stochastic Profit Approach.

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ABSTRACT

The study analyzed the efficiency of sweet potato marketing in the study area. Data were collected with the aid of a well-structured questionnaire from 40 randomly selected sweet potato marketers from 2 purposively selected markets. Data were analyzed using descriptive statistics and stochastic profit function. Results showed that the mean age of the sweet potato marketers was 37 years and majority (57.5%) were female. All the parameter estimates such as cost price of sweet potato, transportation, market space (rent) etc have the expected sign and are statistically significant at 1% and 5% respectively showing that they are important determinants of total profit associated with sweet potato marketing in the study area. The maximum likelihood estimates for the stochastic profit function used in explaining the inefficiency parameters for the sweet potato marketers indicated that all the parameters such as sex, marital status etc except age had the *a priori* expected signs and are all statistically significant showing that an increase in any of them decreases inefficiency. The mean profit efficiency is 0.45 meaning that an average sweet potato marketer in the study area has a scope for increasing profit efficiency by 55%. It was concluded that sweet potato marketers are not profit efficient from their profit efficiency indices.

Key words; Marketing Efficiency, Sweet Potato, Covid-19, Stochastic Profit Frontier.

INTRODUCTION

Sweet potato, a neglected food crop in the past has found its place in the global market because of its ability to respond to the pressing need of boosting food security, wealth creation and nutrition amidst covid-19 pandemic. Sweet potato (*Ipomoea batatas)* is a herbaceous plant that belongs to the family of *Convolvulaceae* and genus of Ipomoea. Nigeria is the largest producer of sweet potato in West Africa (Udemezue, 2019). It is a source of food to humans, while the leaves and roots are used as animal feed. It is a great source of vitamin A (Hagenimana *et al.,* 2000). However, the Covid-19 pandemic according to International Labour Organization (2020) has disrupted the entire food system, preventing farmers from accessing markets and selling their produce, thus disrupting the food supply chain. Anudu (2021) reported that Nigeria's sweet potato production is estimated at 1.2 million MT (Metric Ton) while demand is 6 million MT leaving a supply gap of 4.8 million MT of untapped market potentials. This

could be linked to inefficient marketing system resulting from differentials in transportation cost, storage cost etc. Bridging this demand and supply gap of sweet potato in Nigeria amidst this pandemic through domestic production and efficient marketing offers a great investment potential to the Nigerian populace.
Marketing efficiency refers to the ability to make maximum marketing profit given the purchase and selling prices of the products and the level of fixed factors of the firm. Inefficiency is defined as loss of profit from not operating on the profit frontier (Rahman and Awerije, 2014). The stochastic profit frontier as used by Truong *et al.,* (2020) is defined as where π is the vector of profit defined as gross revenue minus variable cost divided by output price (Py).

$$\pi^* = \frac{\pi}{Py} = \mathrm{f}(Pi, Zi).\exp(Vi - Ui) \ldots. (1)$$

Where π* is the normalized profit computed for the ith firm, Pi is the vector of variable input prices, Py is the output price, Zi is the vector of fixed inputs, and i = 1…n is the number of firms in the sample. Vi is the independently distributed two sided random errors which represents random variations in profit attributed to factors outside the marketers control, Ui is the non-negative random variables associated with inefficiency. When u = 0, it means that the firm's profit is on the efficiency frontier and when u < 0 it means that the firm's profit is below the efficiency frontier. The marketing profit efficiency of an individual firm in this study using stochastic frontier profit function is defined as the ratio of the predicted or actual profit (πi) to the corresponding predicted maximum profit (πi*) for the frontier profit given the price of variable inputs and the level of fixed factors of production of that farmer. The formula is given as:

$$\mathrm{EE} = \frac{\pi i}{\pi i^*} = \frac{(Pi,Z)\ exp(Vi-Ui)}{(Pi,Z)\ exp(Vi)} \ldots.(2)$$

$$\mathrm{EE} = \exp\frac{(Vi-Ui)}{exp(Vi)} \ldots.. (3)$$

Where: EE is the profit of an individual marketer in the context of the stochastic frontier profit, πi is the predicted profit, πi* is the predicted maximum profit for the best marketer or frontier profit given the price of variable inputs (Pi) and the level of fixed factors (Z) used by the marketer. Vi and Ui are as stated above Many studies have been carried out on marketing efficiency of sweet potato and its determinants using parametric and non parametric efficiency measures such as efficiency index ratios, value addition and OLS multiple regression model as can be seen in Ejechi *et al.*, (2016), Girei, *et al.*, (2019), Sarma (2010), and Kyomugis *et al.*, (2018) etc but none of them used stochastic profit frontier. Based on the above, this study therefore examined the following: Socio economic characteristics of the marketers, Marketing efficiency and inefficiency of sweet potato marketers using stochastic profit frontier.

Hypothesis

H_0: Sweet potato marketers in the study area are not profit efficient.

MATERIALS AND METHODS

The study was conducted in Owerri Municipal Council of Imo State. The study area was selected due to the predominance of major markets in the area. Owerri Municipal has a population of about 127,213 according to 2006 population census. It is the head quarters of Imo State. Owerri Municipal area has two main seasons, the dry and wet season. The area has an annual rainfall of between 2250mm to 2500mm with average annual temperature of between 25-27^{0}c and annual relative humidity of 80% (Njoku and Igbokwe, 2021; Nwajei, *et al.*, 2017). Two markets were purposively selected which include the Relief and Owerri main market (Eke Ukwu Owerri). The purposive selection is because of the full business activities that go on in these markets on daily basis compared to those in the rural areas. Simple random sampling was used to select 20 potato marketers (retailers) from each of the 2 markets given a total of 40 marketers. Descriptive statistics was used in describing the socio economic characteristics of the marketers, while stochastic profit frontier was used to determine the profit efficiency and inefficiency of the marketers.

Stochastic Profit Frontier Function

Following Truong *et al*., (2020) the stochastic profit frontier was used to estimate the marketing profit efficiency of the marketers in the study area. The explicit Cobb-Douglas profit frontier for sweet potato marketers is specified as;

$$\mathrm{Ln}\pi^* = \beta_0 + \sum_{j=1}^{6} \beta_j \mathrm{Ln}X_{ij}^* + \beta_k \mathrm{Ln}X_k + \nu i - \mu i \quad \ldots\ldots (4)$$

Where, Ln = Natural Log, Lnπ^* = Natural Log of profit function, X_1^*= Cost price of Sweet Potato (₦/kg), X_2^* = Cost of loading and off loading (₦/kg),X_3^*= Cost of transportation (₦/kg), X_4^*= Cost of storage (₦), X_5^* = Rent (Market space) (₦), X_6^* = Association fee (₦), $\beta_1 - \beta_6$ = Parameters to be estimated, β_0 = Constant term, ν_i = Two sided random error, μ_i = One sided random error, e_i = ν_i- μ_i = Error Term. The inefficiency model (μ_i) is specified thus: μ_i = a_0 +$a_1 Z_1$ + $a_2 Z_2$ + $a_3 Z_3$ + $a_4 Z_4$ + $a_5 Z_5$ + $a_6 Z_6$ + $a_7 Z_7$……… (5) Where, Z_1 =Age (years), Z_2 = Sex (2, Male; 1, Female), Z_3 = Marital status (4, Married; 3, Single; 2, Widowed; 1, Divorced), Z_4 = Household size (Number of persons), Z_5 = Years of Education (Years), Z_6 = Marketing Experience (Years), Z_7 = Member of marketing Association (2, Yes; 1, No), a_0 - a_7 = Parameters to be estimated.

RESULTS AND DISCUSSION

Table 1: Socio Economic Characteristics of Sweet Potato Marketers.

Variable	Frequency	Percentage (%)
Age (Years)		
21-30	6	15.0
31-40	22	55.0
>40	12	30.0
Mean = 37		
Sex		
Male	17	42.5
Female	23	57.5
Marital Status		
Single	12	30.0
Married	18	45.0
Widowed	8	20.0
Divorced	2	5.0
Household Size (No. of Persons)		
1-4	14	25.0

5-8	20	50.0
>8	6	15.0
Mean 5 persons		
Years of Education		
1-6	13	32.5
7-12	23	57.5
>12	4	10.0
Mean = 8		
Marketing Experience (years)		
1-10	15	37.5
11-20	19	47.5
>20	6	15.0
Mean = 9		
Marketing Association		
Yes	32	80.0
No	8	20.0

Field Survey Data 2022

Table 2: Maximum Likelihood Estimates of Stochastic Frontier Function

Variables	**Parameters**	**Coefficients**	**Standard Error**	**t-ratio**
Constant Term	β_0	0.9622***	0.1074	7.45
Cost Price of sweet potato	β_1	-1.07381***	0.1753	-6.64
Cost of loading /off loading	β_2	-3.1079**	1.0744	-2.80
Cost of Transportation	β_3	-0.7223***	0.2624	-5.40
Cost of Storage	β_4	-4.2527**	1.6542	-2.66
Rent (Market Space)	β_5	-3.3317***	0.6754	-5.85
Association Fee	β_6	-6.7761**	2.0833	-3.02
Inefficiency Effects				
Age	a_1	0.8710**	0.2845	2.97
Sex	a_2	-0.7334*	0.3521	-1.91
Marital Status	a_3	-0.6643**	0.3255	-2.77
Household Size	a_4	-0.7116*	0.0267	-1.97
Years of Education	a_5	-0.1475**	0.0770	-2.75
Marketing Experience	a_6	-0.8481***	0.1975	-5.71
Member Marketing Asso	a_7	-4.8432**	1.7053	-2.90
Diagnostic Statistics				
Sigma Squared	**0.1152**			
Wald Chi^2	**46455.04**			
Prob > Chi^2	**0.0000**			
Log-Likelihood	**-1025.83**			
F-Test Value	**102.52*****			

Note: *** Significant at P ≤ 0.01, ** Significant at P ≤ 0.05, * Significant at P ≤ 0.10.
Source: Field Data, 2022.

~~Table 3: Marketing Efficiency Scores of Sweet potato Marketers~~

Efficiency Scores	Frequency	Percentage
0.11-0.21	4	10.0
0.22-0.32	5	12.5
0.33-0.43	10	25.0
0.44-0.54	9	22.5
0.55-0.65	5	12.5
0.66-0.76	7	17.5
Total	**40**	**100**
Mean	**0.45**	
Minimum	**0.11**	
Maximum	**0.75**	

Source: Field Data, 2022.

The socio-economic characteristics of the sweet potato marketers are presented in Table 1. The results show that the sweet potato marketers have a mean age of 37 years, 57.5% were female. This indicates that young women are more in sweet potato marketing which is in line with the findings of (Udemezue, *et al.*, 2018). The results also show that majority of the marketers (80%) belongs to marketing association with half of the respondents (50%) having household size of 5-8 persons. This is contrary to the findings of (Nkamigbo *et al.*, 2021). Majority (45%) are married with a mean marketing experience of 9 years and have spent some years in school showing that they are literates which is in line with (Ejechi *et al.*, 2016). The result of the maximum likelihood estimates of the stochastic profit frontier model is presented in Table 2. The elasticity values of the 6 parameter estimates were negative and have the expected signs and are statistically significant at 1% and 5% respectively. This shows that these factors (cost of sweet potato, loading and off- loading, transportation, storage, rent and association fee) are important determinants of total profit associated with sweet potato marketing in the study area. This result confirms the findings of (Odondo *et al.*, 2014). The maximum likelihood estimates for the stochastic profit function used in explaining the inefficiency parameters for the sweet potato marketers is also presented in Table 2. The coefficients of six (sex, marital status, household size, years of education, marketing experience and marketing association) out of the seven variables used had apriori expected signs and are significant at 1%, 5% and 10% respectively indicating that increase in them decreases inefficiency except for age which has positive relationship with marketing inefficiency (Konja *et al.*, 2019). The marketing profit efficiency scores is presented in table 3. The marketing efficiency of the sampled marketers ranged from 0.11 to 0.75. The mean profit efficiency is estimated to be 0.45, meaning that an average sweet potato marketer in the study area had a profit inefficiency gap of 0.55 leading to the acceptance of the null hypothesis.

CONCLUSION

The sweet potato marketers are not profit efficient because their marketing (profit) efficiency indices indicates that there are still inefficiency gaps to be filled in other to operate fully on the profit frontier.

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Cost and return analysis of small-scale date palm producers in Jigawa State, Nigeria

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ABSTRACT
The study "Cost and return analysis on date palm (*phoenix dactylifera L.*) production among small-scale farmers in Jigawa state" a total of one hundred and thirteen (113) farmers from twelve (12) villages, were selected from two (2) Local government areas using multi-stage sampling procedure. Data were collected by the use of structured questionnaires; the data were analyzed using descriptive statistics and net farm income. The findings of this study revealed that the small-scale date palm farmers had a mean age of 51 years, the mean household size of 13 people and mean years of experience is 32 years, most 99% were married, 30% of the date palm producers had formal education, and about 11% were members of farmers' cooperative society. The total costs and return were estimated at ₦120,094.70 and ₦136,817.04 respectively, and a return on Naira investment of ₦1.14. Inadequate water source, inadequate government and private organisations intervention and inadequate awareness were the major constraints to small-scale date palm producers in Jigawa state. It was concluded that date palm production is a profitable enterprise, but most of the small-scale date palm farmers are realizing the best out of their investment.

INTRODUCTION
The new federal Agricultural Promotion Policy (APP) strategy focuses on solving the core issues at the heart of limited food production and delivery of quality standards (FMARD, 2016). As productivity improves domestically and standards are raised for all Nigerian food production, export markets will also benefit impacting positively on Nigeria's balance of payments. Crop sector plays a crucial role in rural economy and livelihood. This is one sector where the poor contributes to the economic growth directly instead of getting benefit from economic growth generated elsewhere. In Nigeria, the crop sector forms an important livelihood activity for most of the farmers, supporting agriculture in the form of critical inputs, contributing to the health and nutrition of the household, supplementing incomes, offering employment opportunities, and serving as a store of wealth in times of need. It acts as a supplementary and complementary enterprise.

Date palm fruit is important as a part of agriculture diversification and income enhancement. In 2020/2021 date fruit were the dried fruits most producing globally, and Saudi Arabia was leading producer of dates and account for about 21% of global production. (INC statistics, 2020-2021). Nigeria is not listed among the dates producers at the international scene, which may be attributed to dearth of information on the Nigeria date palm production sector. Chukwuemeka, (2013) urged Federal government to include date palm production in the Agricultural Transformation Agenda (ATA) Programme to ensure food security and combat desertification.

Nigeria is facing two key gaps in agriculture today: inability to meet domestic food requirements, and an inability to export at quality levels required for market success (FMARD, 2016). The former problem is a productivity challenge driven by an input system and farming model that is largely inefficient. As a result, an aging population of farmers do not have enough seeds, fertilizers, irrigation, crop protection and related support to be successful. The Nigerian date palm production is estimated at about 21,700 metric tonnes (AbdulQadir *et al.*, 2011), but due to the subsistence cultivation, the total area put into Date Palm production is not more than 1,446.8ha in Nigeria (Dada *et al.*, 2012), and the estimated consumption of date is put at 89,850 metric tonnes (Sani *et al.*, 2010), this shows that Nigeria can produce only 24% of its consumed date, the remaining 76% of date consumed in Nigeria are imported from the neighboring countries like Chad and Niger.

Despite the power vested on Nigerian Institute For Oil Palm Research (NIFOR) to provide new technologies and innovations on how to enhance and improve date palm production and productivity, it was discovered that the date palm production is trying to become history due to the urbanization of areas like Dutse Local Government Area (LGA) of Jigawa state, in which number of hectares under the possession of small scale date palm farmers were revoked by the government for other urban purposes, the trees were cut down without replacement. This brought about a large deficit in the date palm production in Jigawa State. The number of hectares and total date production in Nigeria was from a single source since 2010. There is no source that reported the cost and return analysis to ascertain the profitability of date palm production.

Datre palm has a comparative advantage in the area of study for having two growing seasons in a year. The cultivation of date is at subsistence level, with farmers having few trees stands on their farms and two or more stands in their homestead. However, no information is available on the production capacity as well as its costs and return structure in the country (Dada *et al.*, 2012). This study therefore sets to address the knowledge gap on the date's cost of production and profitability. The main objective of this research is to analyse the economics of date palm production in Jigawa state. The specific objectives are to;

i. describe the socio-economic characteristics of date palm farmers,
ii. determine the costs and return associated with date palm production,

Justification

The study focused on the economics of date palm production among small-scale producers in Jigawa State. This study is expected to provide valuable information on costs and return of date palm to enable farmers consider its production as a viable option. The findings of this study would help farmers and other agencies in identifying problems facing date palm producers for improvements, it will also be useful to both government in decision making and non-governmental organizations with a view to promote the date palm production. Similarly, the study would provide valuable information to the government of Jigawa State, as a basis for policy formulation for date palm production in the State, it is hoped that this work would be of assistance to researchers and add to the existing knowledge in date palm production among small-scale producers in Jigawa State.

Limitation

- ✓ There was a difficulty in measuring the farm size of the date palm farmers, this is due to the fact that majority of respondents interviewed for this study had their date palm trees in a scattered location, this gives room to exclude land size as a factor in the study.
- ✓ Current literature on date palm production exists, but there are less literatures and publications on the economics of producing date palm trees in Nigeria, and inadequate literatures on how to classify the date palm farmers into small scale, medium and large-scale producers. This give room to the study to categorise the producers scale based on farmers perspective, in which the small-scale farmers are categorised as those that own one (1) to twenty (20) trees, twenty-one (21) to fifty (50) trees as medium scale while fifty and above (>50) trees as a large-scale farmer.
- ✓ There was a dearth of information on the farmers' previous production record, and majority of the small-scale date palm producers owned date palm trees by inheritance, gift and purchase. This gives room to take the average purchase price of trees as the initial cost production and to use one seasonal data (i.e., 2016) to measure costs and return using Net Farm Income in date palm production in the study area.

MATERIALS AND METHODS (METHODOLOGY)

The study area: Jigawa State is situated in the north-western geopolitical part of the country between latitude 11.00^0 North to 13.00^0North and longitude 8.00^0East to 10.15^0East and a total landmass of 24,742 square kilometres (Jigawa 2009), a large proportion of this is certified to be arable land, with an estimated population of about 8,109,251 million (T.I.N. Magazine 2017), 85% of the population in the state lives in the rural areas (Jigawa, 2009). Jigawa State shares an international border with the Republic of Niger. This provides unique opportunities for international trade of date palm fruit produced in Niger and Nigeria. Annual rainfall is estimated to be between 600mm - 1,000mm with an average of about 650mm over the last few years. Rainfall in the state normally lasts an average of five months (May to September), the temperature ranges from 10^0C during the harmattan season to about 42^0C during the dry season and annual mean relative humidity of 30.8% (Jigawa, 2009).

Sampling Procedure: A multi-stage sampling technique was used in this study. two Local Government Areas were purposively selected from 'zone I' of Jigawa State Agricultural and Rural Development Authority Zones, namely; Dutse and Kiyawa due to the concentration and high intensity of date palm production in these areas, two wards from each local government were purposively selected, three villages were purposively selected from each ward. A simple census was conducted in each village and a total of 159 were identified and verified to be the small-scale date palm farmers. from each village 71% of the total population of each village was randomly selected, using random selection without replacement method, this gives a sample size of 113 small-scale farmers.

Data Collection: Primary data were used as a source of information in this study. The data was collected with the aid of a structured questionnaire administered to the date palm producers.

Data Analysis: Simple descriptive statistical tools such as mean, standard error, frequency and percentages were used for the socio-economic characteristics of the farmers, while, Net Farm Income was used to estimate the cost and returns in date palm production.

Model Specification for Net farm income: Net farm income (NFI) was employed for estimating the cost and returns in date palm production in order to see the profitability of date production in Jigawa State, it is expressed as:

NFI = TR – TC … (1)

TR = Total Output (kg) X Unit Price of the Output (₦/kg)

TC = TFC + TVC …(2)

Where;

NFI - Net Farm Income in Naira (₦)/Season
TR - Total Revenue in Naira (₦)
TC - Total Cost in Naira (₦)
TFC - Total Fixed Cost in Naira (₦) (Depreciation on hoe, knife, tube-well and watering can)
TVC - Total Variable Cost in Naira (₦) (organic fertilizer, pollen, net, jude sack, polyethene sack and rope).

GR = TC/GI …(3)

GM = GI - TVC …(4)

RI = GI/TC …(5)

Where;
GR - Gross Ratio
GI - Gross Income
OR – Operating Ratio
GM – Gross Margin
RI – Return on Naira Invested

RESULTS AND DISCUSSION

Socio-economic characteristics of small-scale date palm producers

Socio-economic characteristics used for this study were age, sex, household size, years of experience, marital status, and educational status of the small-scale date palm producers.

The result from Table 1 reveals that for Gender (sex) 100% are male, 34% are between the age range of 60-70years followed by the 38-48years. The mean age of 51 years and the category of farmers that has 34% indicates that majority of small-scale date palm farmers were above active age group. This may be due to the poor participation and practicing of date palm production by the middle age group, few among the middle age group are planting new set of date palm trees in the study areas. This does not conform to *a priori* expectation, as middle age farmers are expected to be the occupants of the production for its tedious nature. This finding did not conform with that of Gbolagade *et al.* (2013) who in the same location reported that 53% of the date palm farmers were in their active age group between 31 – 50 years.

Household Size: The result presented in Table 1 reveals the 46% of the household are between 4 – 10 person per household. This indicates that majority of the sampled farmers have household size that is larger than 5, it is expected that large number of household size could contribute a lot to the family labour and increases productivity which is in line with expectation among the small-scale date palm farmers.

Years of Experience: Table 1 reveals that the farmers had a mean age of 32 years. This shows that small-scale date palm farmers gained some level of expertise over the years, which further gave them a better understanding of the factors affecting their production. But still the years of experience doesn’t change the understanding of the date palm farmers in Jigawa state on the adoption of new technologies on date palm farming.

Marital Status of Small-Scale Date Palm Farmers: Result in table 1 reveals that majority of the respondents with 99.1% were married, this finding is similar to that of Gbolagade *et al.* (2013) who discovered in the same location that 99.1% of date palm farmers were married. This shows that majority of small-scale date palm farmers were responsible and good in decision making.

Educational Status: the result reveals that 70% had no formal education, this indicates that majority of the respondents don’t have formal education. This finding is in line with that of (Salman, 2011) who reported that 59.2% of the respondents had no formal education.

Membership of Farmer Groups/Cooperatives: Table 1 revealed that 89.4% are non-members of farmer groups, this is because most of the farmers believe that they will not have supports or access to any other important input on date palm production.

Table 1: Age, household size, years of experience of SSDPF

Items	Frequency	(%)	Mean	SD.
Age			51	12
27– 37	12	10.6		
38– 48	37	32.8		
49– 59	25	22.1		
60– 70	38	33.7		
71– 81	1	0.9		
Household size (No.)			13	6
4 – 10	52	46.0		
11 – 17	34	30.1		
18 – 24	21	18.6		
25 – 31	5	4.5		
32 – 38	1	0.9		
Experience (years)			32	13
06 – 17	14	12.4		
18– 29	24	21.3		
30– 41	51	45.2		
42– 53	19	16.8		
54– 65	5	4.4		
Marital Status				
Single	1	0.9		
Married	112	99.1		
Educational status				
Non-Formal	79	69.9		
Primary	24	21.2		
Secondary	4	3.5		
Tertiary	6	5.3		
Group membership				
Member	12	10.6		
Non-member	101	89.4		
Total	**113**	**100**		

Costs and return analysis

Table 2 depicts the various cost components involved in the date palm production in Jigawa state. Table 2 reveals the average number of date palm trees as 12 trees for a small-scale farmer with a minimum and maximum of 1 and 20 trees respectively. Net farm income for small scale date palm farmers is calculated as ₦11,057.17/stand/annum, this was computed based on the average of total operational costs and depreciated total fixed costs of ₦11,445.77 and ₦1,796.70 respectively, this give a total production cost of ₦13,242.47 on average small scale date palm farmer and gross income (return) of ₦24,299.64/stand per annum.

The result shows that cost of purchasing trees has the highest percentage accounting for about 51.25 percent of the total cost of production and 59.29 percent of the total variable cost, followed by labour cost accounting for about 14.35 percent of the total cost of production and 16.60 percent of the total variable cost, and this may be due to the tedious nature of the work (i.e. climbing trees for dethorning, pollination, covering and tie-down of bunches and cut down of fruit bunches).

Total variable cost accounted for about 86.43 percent while fixed cost accounted for 13.57 percent of the total cost of production. The net farm income calculated as ₦11,057.17

/tree/annum and a gross margin of ₦12,853.87 /tree/annum this implies that the date palm production among small scale producers is profitable. If necessary adjustments are made within the production such as increasing the number of tree stand, the return per naira invested of 1.83 can be increased (Olukosi and Erhabor 2008), and it can help the small-scale date palm farmers to increase their income and improve their livelihood.

Table 2: Costs and Return Associated with Small-Scale Date Palm Producers

Variable inputs	Quantity	Cost (₦/ha)	%TC	%TVC
Trees (Number)	1	6,786.77	51.25	59.29
Labour (Man-days)	2	1,900	14.35	16.60
Organic Fertilizer (kg)	40.05	387	2.92	3.38
Pollen (g)	7.45	157.85	1.19	1.37
Net (Number)	1	320	2.42	2.79
Jude Sack (Number)	3.5	290	2.19	2.53
Pesticides (Liters)	10cl	85	0.64	0.74
Polyethene Sack (Number)	2	120	0.91	1.05
Rope (Roll)	1	225	1.70	1.97
Transportation		1,174.15	8.87	10.26
Total Variable Cost		**11,445.77**	**86.43**	**100**
Fixed Inputs				**%TFC**
Hoe (Number)	1.14	130.52	0.99	7.26
Tube Well (Number)	1	1,436.96	10.85	79.98
Knife (Number)	1.27	86.55	0.65	4.82
Watering can (Number)	1	142.67	1.08	7.94
Total Fixed Cost		1,796.7	13.57	**100**
Total Cost		13,242.47	**100**	
Gross Income (Returns)		**24,299.64**		
Net Farm Income		**11,057.17**		
Gross Margin		**12,853.87**		
Gross Ratio		0.54		
Return on Capital Investment		**1.83**		

CONCLUSION

Based on the findings of this study on costs and return analysis it could be concluded that date palm production is a good enterprise for income generation, job creation and enhancement of livelihood among farmers in Jigawa State.

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Assessment of post-harvest management training needs for tomatoes farmers in Niger state, Nigeria

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ABSTRACT
This study Assessed Post-harvest Management Training Needs for Tomatoes Farmers in Niger State, Nigeria**.** Sample size of one hundred and eighty (180) maize farmers were selected using multi-stage sampling method. Structured questionnaire complimented with interview scheduled were used for data collection. Data collected were analyzed using descriptive statistics such as (frequency, percentages and mean) The finding showed that processed of tomatoes to paste ($\bar{X}$ =2.41), sorting according to size and colour ($\bar{X}$ =2.33) and use of cold water bath ($\bar{X}$ =2.32) were the most important training needs for tomato farmers in the study area. The most constraints associated with post-harvest management in the study area were shortage of fund ($\bar{X}$ =3.76), inadequate credit facilities ($\bar{X}$ =3.68), and high cost of post-harvest materials ($\bar{X}$ =3.61). It is recommended that farmers should source for credit and fund from informal sources in order to address the problem faced in the study area. Also, the price of post-harvest material should be made flexible and avoidable for farmers in the study area.
KEYWORDS: Post-harvest; Training; Needs; Tomato Farmers.

INTRODUCTION
Tomato (Lycorpesicon esculentum) is vital at supplying human populace with vitamins and minerals required for growth and development. Tomatoes in Nigeria are mostly produced in Northern Nigeria as a result suitable agro-climatic condition that favoured mass production. Tomatoes are either used fresh or processed into paste. Unfortunately, they are not only seasonal but highly perishable and deteriorate due to lack of proper knowledge on post-harvest management and inadequate training needs by tomato farmers (Mohammed *et al.,* 2012). Tomatoes farmers post-harvest training needs in sorting, grading, processing, transportation, preservation and diseases control are expected to enhance longevity of tomatoes and reduce post-harvest losses that are accounted for more than 50% of the tomato produced in Nigeria (Muhammed *et al.,* 2015). A need-based training would bring a desirable alteration in the skills, knowledge and attitude of the farmers. Training enhances perfection and confidence in farmers. The objective of the study are to assess the post-harvest management training needs for tomato farmers and identify the constraints associated with post-harvest management in the study area.

MATERIALS AND METHODS

The researched was done in Niger State of Nigeria. the state can be found in the guinea savannah ecological zone of nigeria. The State is located within Longitude 3° 30' and 7° 20' east & Latitude 8° 20' and 11° 30' north, with a population of about 3,950,249 (npc, 2006) and with a growth rate of 3.2%, the state has estimated population of 5,586,000 in 2017 (Niger State Geographical Information System, 2015). Some of the tree crops are rice, beans, tomato, melon, guinea corn etc.

Multi-stage sampling technique was employed for this study. the first stage involved random selection of three (3) agricultural zones in the state. the second stage involved the selection of one (1) Local Government Areas (LGAs) from each of the zones making a total number of three (3) LGAs. the third stage involved random selection of four (4) communities each from the selected LGAs making a total of twelve (12) villages. the fourth stage involved the use of proportional sampling to select 10% of the farmers from the sampling frame which gave a total sample of one hundred and eighty (180) respondents.

Table 1: Showing sample distribution of the farmers in the study area

State	Agricultural Zones	LGAs	Communities	Sampling Frame	Sample Size (10%)
Niger State					
	Zone I	Lapai	Egba	400	40
			Dagana	81	8
			Jedna	82	8
			Gbacinku	108	11
	Zone II	Paikoro	Adunu	130	13
			Gwallo	94	9
			Kaffi	59	6
			Nikuchi	126	13
	Zone III	Mariga	Bangi	240	24
			Beri	54	5
			Bobi	330	33
			Wamba	102	10
Total	**3**	**3**	**12**	**1806**	**180**

Sources: Niger State Agricultural Mechanization and Development Authority (2016)

Primary data was used for this study. Data were collected by the researcher assisted by trained enumerators using structure questionnaire complimented with interview schedules. The objectives of this study were achieved using descriptive statistics such frequency distribution, percentage

Analytical Techniques

Post-harvest training needs of tomato farmers was measured using 3-points likert scale of Most important 3, Important 2, Not important 1. A mean score of 2.0 was obtained by adding 1+2+3=6 and dividing by 3. The decision rule was any mean ($\overline{X}$) scores > 2.0, indicates important, while scores < 3.0 is termed not important**.** The Constraints associated with post-harvest management of tomatoes were measured using 5-point Likert scale, and was allotted as follows: Very severe 5, Severe 4, Undecided 3, Less severe 2, Not severe 1. A mean score of 3.0 was obtained by adding 1+2+3+4+5=15 and dividing by 5. The decision rule was any mean ($\overline{X}$) scores > 3.0, indicates severe, while scores < 3.0 is termed not severe

RESULTS AND DISCUSSION

Post-harvest training needs of tomato farmers

Table 1 showed that the most important post-harvest training needs were processing of tomatoes into paste ($\bar{X}$ =2.41), size and colour sorting ($\bar{X}$ =2.33), use of cold water bath ($\bar{X}$ =2.32), use of open air dry ($\bar{X}$ =2.28), store in cool place ($\bar{X}$ =2.21) and fully and half ripe grading ($\bar{X}$ =2.21) ranked 1st, 2nd, 3rd, 4th and 5th respectively. The findings is in consonance with Muhammed *et al.* (2012) who reported tomatoes growers in Kano State, Nigeria were fully involved in sorting, grading and conversion of tomatoes to paste. Other important post-harvest management training needs in the study area include use of motorcycle for transporting tomatoes ($\bar{X}$ =2.19), use of crates for packing ($\bar{X}$ =2.18), keep tomatoes away from sunlight ($\bar{X}$ =2.15), use of traditional baskets, use of public transport ($\bar{X}$ =2.08) and sundried tomatoes into chips ($\bar{X}$ =2.07). This finding agreed with Azad *et al.* (2014) who stated that use of crate and traditional basket reduces deformities experience by tomato growers.

Table 1: Post-harvest training needs for tomato farmers

Training needs	Most important	Important	Not important	Sum	Mean	Rank	Decision
Sorting							
Size and colour sorting	77 (42.8)	86 (47.8)	17 (9.4)	420	2.33	2nd	Important
Grading							
Fully and half ripe	60 (33.3)	99 (55.0)	21 (11.7)	399	2.21	5th	Important
Packing materials							
Use of Nylon sacks	15 (8.3)	35 (19.4)	130 (72.2)	245	1.36	15th	Not important
Use of traditional baskets	45 (25.0)	110 (61.1)	25 (13.9)	380	2.11	10th	Important
Use of crates	58 (32.2)	96 (53.3)	26 (14.4)	392	2.18	8th	Important
Storage methods							
Store in cool place	65 (36.1)	88 (48.9)	27 (15.0)	398	2.21	5th	Important
Keep them away from sunlight	63 (35.0)	81 (45.0)	36 (20.0)	387	2.15	9th	Important
Transportation methods							
Use of public transport	46 (25.6)	102 (56.7)	32 (17.8)	374	2.08	11th	Important
Use of motorcycle	68 (37.8)	78 (43.3)	34 (18.9)	394	2.19	7th	Important
Use of fuel tanker	16 (8.9)	55 (30.6)	109 (60.6)	267	1.48	13th	Not important
Use of human labour	9 (5.0)	42 (23.2)	129 (71.7)	240	1.33	16th	Not important
Preservation methods							
Sundried into chips	52 (28.9)	89 (49.4)	39 (21.7)	373	2.07	12th	Important
Use of open air dry	99 (55.0)	34 (18.9)	47 (26.1)	412	2.28	4th	Important
Use of refrigerator	4 (2.2)	67 (37.2)	109 (60.6)	255	1.42	14th	Not important
Use of cold water bath	82 (45.6)	73 (40.6)	25 (13.9)	417	2.32	3rd	Important
Processing of tomatoes							
Processed to juice	1 (0.6)	73 (40.6)	106 (58.9)	255	1.42	17th	Not important
Processed tomatoes paste	86 (47.8)	82 (45.6)	12 (6.7)	434	2.41	1st	Important

Sources; Field survey, (2018)

Constraints associated with post-harvest management

Table 2 revealed that the most severe constraints associated with post-harvest management in the study area were shortage of fund ($\bar{X}$ =3.76), inadequate credit ($\bar{X}$ =3.68), high cost of post-harvest materials ($\bar{X}$ =3.61), inadequate training on post-harvest management ($\bar{X}$ =3.48). The findings agreed with Mohammed *et al.* (2018) who indicated that shortage of fund and inadequate access to credit were the major constraints affecting soya bean production in Northern Region of Ghana. Similar findings by Maxwell (2014) showed that inadequate access to credit was the most serious constraints affecting rice farmers in Sub-Sahara Africa. Other severe constraints in the study area were inadequate infrastructure ($\bar{X}$ =3.24), knowledge and skills limitation ($\bar{X}$ =3.33), lack of technical knowledge ($\bar{X}$ =3.27), limited knowledge on post-harvest management ($\bar{X}$ =3.27). These findings agreed with Elisha *et al.* (2016) who stated that inadequate infrastructure and knowledge and skills limitation were the major constraints faced by smallholder farmers in Ghana

Table 2: Distribution according to constraints associated with post-harvest management

Variables	Mean ($\bar{x}$)	Rank	Decision
Quick deterioration of crops	2.99	9th	Not severe
Inadequate credit	3.68	2nd	Severe
Inadequate market information	2.79	13th	Not severe
Inadequate trainings on post-harvest	3.48	4th	Severe
Shortage of fund	3.76	1st	Severe
High cost of post-harvest materials	3.61	3rd	Severe
Lack of farmers participation	2.98	10th	Not severe
Lack of technical knowledge	3.27	7th	Severe
Knowledge and skills limitation	3.33	6th	Severe
Insect attack	2.84	12th	Not severe
Limited knowledge on post-harvest management	3.27	7th	Severe
Disease Attack	2.88	11th	Not severe
Inadequate infrastructure	3.42	5th	Severe
Theft of produce	2.66	14th	Not severe
Reduction in taste qualities	2.48	16th	Not severe
Use of fake chemical	2.62	15th	Not severe

Sources; Field survey, (2018)

CONCLUSION AND RECOMMENDATIONS

Based on this finding it can be concluded processed tomatoes to paste, size and colour sorting, use of cold water bath and use of open air dry were the most post-harvest training needs for tomatoes farmers in the study area. The most severe constraints associated with post-harvest management in the study area were shortage of fund, inadequate credit and high cost of post-harvest materials. It is recommended that farmers should source for credit and fund from informal sources in order to address the problem faced in the study area. Also, the price of post-harvest material should be made flexible and avoidable for farmers in the study area.

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Packaging, Handling and Storage of Onion (*Allium Cepa L.*): A case Study of *Sabon Gari* Market, Zaria, Nigeria.

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ABSTRACT

This work was carried out to investigate packaging, handling and storage practises of farmers and onion marketers in Zaria, northern Nigeria. Needed information were obtained through interviews and physical observation on the current practices used in storage, handling and packaging of onions from farmers and marketers. It was observed that onions were packaged in jute gunny bags, baskets made from palm fonds or bamboo and polythene bags. 30% of the respondents who are farmers and 20% of the respondents who are marketers actually and properly cure onions prior to storage. 60% of the respondents who are farmers and 50% of the respondents who are marketers properly sort onions prior to storage, floor storage of onions in poorly ventilated rooms or stead was the common practise of onion storage amongst the farmers and marketers.

INTRODUCTION

Onion (Allium cepa L.) is a vegetable crop, which belongs to the family Alliaceous. It is an important vegetable crop in Nigeria based on nutritional and medicinal values. Oladeji (2018) reported that Nigeria ranks sixth amongst the top ten producers of green onion, and eleventh in terms of dry onion production in the world. The crop is grown for its bulbs, which are used daily in every home for seasoning and flavouring of foods. Onion is a valuable ingredient in the diet due to its sugar, vitamin and mineral contents (Ole et al., 2004).

There are different types of storage structures used in different parts of the country. Most of these structures lack proper ventilation resulting in higher storage losses. The poor aeration and air movement resulted in rise of storage temperature, which in turn adversely affects the product physiology and pathology (Olanipekun, 2018). Olanipekun (2018) reported that Nigeria loses as much as 50% of its onion harvest due to postharvest losses as a result of poor postharvest practices occurring throughout the onion value chain, especially during transit. Gaps in knowledge on how to grade bulbs for marketing, how to properly handle, package and how to manage stored produce accentuate losses. With only few and poor storage facilities available, farmers are forced to sell the products at low prices during glut periods, reducing their income.

This work seeks to investigate the packaging, handling and storage practices of onion by farmers and marketers, the problems associated with such practices and to seek remedy to such practices. This study would be advantageous to onion farmers, marketers and consumers.

METHODOLOGY

Study Area

The study area is located at Sabon Gari in Zaria, Kaduna State at approximately latitude 11.0855°N and longitude 7.720°E from the equator as shown in Figure 1. The market location can be considered to be strategic as it is located at the middle of Zaria metropolis

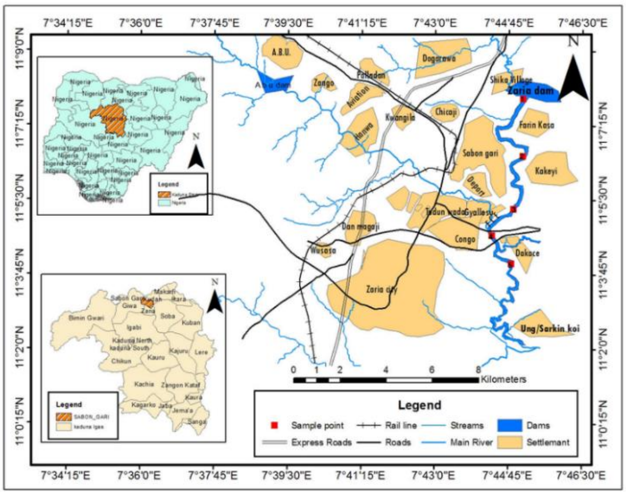

Figure 1: Study Area Map

Sampling Techniques

The sample of the study were the onion farmers and marketers selected through random sampling. In order words, it is the number of respondents which their responses were taken into consideration while taking the decision of the study. To be precise, random sampling technique was employed, this is a method by which selection of few individual member of the population is done in such a way that every other of the population has been represented.

Data Collection and Analysis

Needed information were obtained from a total of 20 farmers and marketers through oral interviews conducted by the researcher and physical observation on the current practices used in packaging, handling and storage of onions. Questions asked during the interview are presented in Appendix A-1. The Camry EK535 digital weighing balance was used to measure the weight of the onions in the packaged sack and a digital camera was used for photo capturing. The data collected were analysed by means of percentages and presented with statistical charts.

RESULTS AND DISCUSSION

Information was obtained from 5 farmers, 12 marketers and 3 respondents who doubled as farmers and marketers. Relevant questions were asked and on market physical observations were made. The farmers and marketers were able to answer the questions both individually and in groups. The results are presented in sections as follows.

Packaging Method

The results of the packaging methods employed by onion marketers and farmers as obtained from the respondents is shown in Table 1 and Figure 2

Table 1: Packaging Methods of onions

	Packaging Container	**Packaging Size**
Farmers	Jute Gunny Bags and Baskets	Large Sack (*solo*)

Wholesalers	Jute Gunny Bags	Large Sacks (*solo*) and ½ *solo*
Retailers	Jute Gunny Bags, Baskets from (palm fronds or bamboo) and Polythene bags	Variety of sizes based on Demand

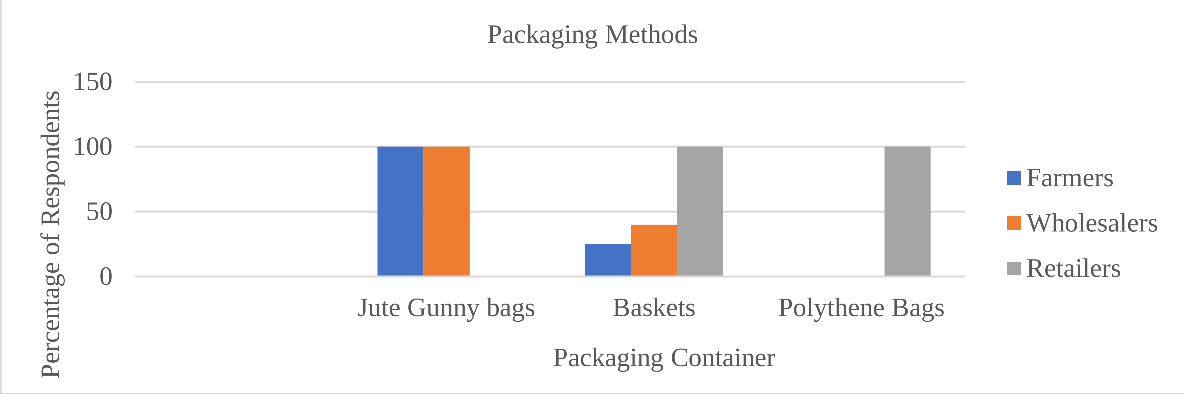

Figure 2: Packaging Methods amongst Farmers and Marketers

It was observed from Figure 2, that onions are mainly packaged in Jute gunny bags (sack), baskets and polythene bags. The largest packaging sack is locally known as '*solo*' weighing about 130kg. The jute bags or sacks are majorly utilized by farmers and wholesalers. Baskets made from palm fonds or bamboo are also used by farmers and marketers. Baskets come in different sizes depending on the quantity intended to be packaged. Large baskets are used by few farmers and wholesalers while the smaller baskets are utilized by retailers. Polythene bags are used solely by retailers.

The Polythene bags doesn't allow for sufficient aeration in the packaged onions, the baskets do not have a top cover, thereby, subjecting the packaged onions to influx of pests, diseases, dust and direct sunlight. The Jute gunny bags, allows for little aeration and protection from pests but when packaged weighing about 130kg, would not allow for ease of inspection especially when any of the bulb is injured or damaged.

<u>Handling Method</u>

The results of the handling methods employed by onion marketers and farmers as obtained from the respondents is shown in Table 2 and Figure 3

Table 2: Methods of handling and transportation of onions

	Handling and Transportation Method
Farmers and Wholesalers	Large trucks like *9 11*, lorries and large pickup vans
Large Scale Retailers	Small trucks like *J5* and cars
Small Scale Retailers	Motorcycle, cars and wheelbarrow.

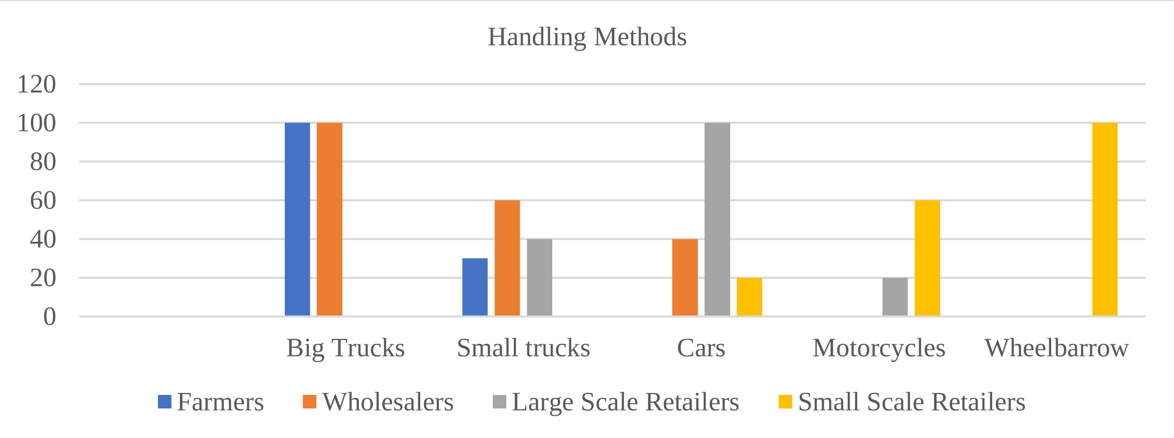

Figure 3: Handling and Transportation methods amongst Farmers and Marketers

It was observed as presented in figure 3 that, all respondents who were wholesalers and farmers utilize big trucks in handling and transporting onions, the middle men and retailers package onions in smaller gummy bags, baskets and uses wheel barrow, motorcycles, and cars as a mode of transport and handling and all small-scale retailers uses wheelbarrow for handling and transporting onions.

These methods of handling usually cause mechanical damage to the onions bulbs which in turn causes spoilage especially when used for long distance journey.

Storage method

The result for sorting and curing by onion farmers and marketers is presented in figure 4.

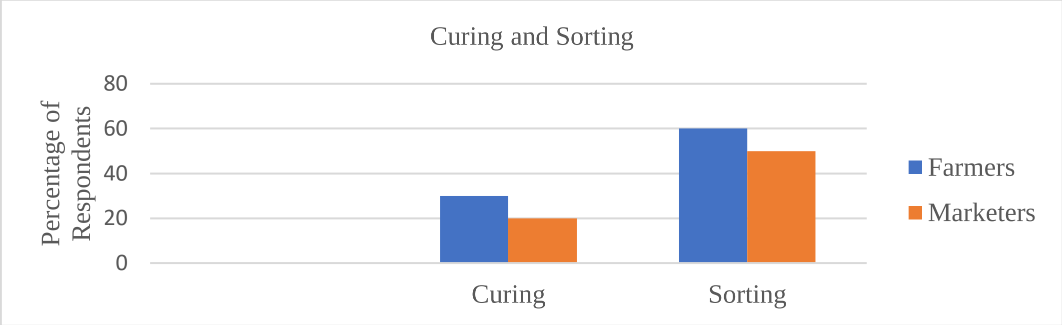

Figure 4: Curing and Sorting by onion farmers and marketers

It was observed as presented in Figure 4 that only 30% of the respondents who are famers, 20% who are marketers actually and properly cure onions prior to storage. 60% of the respondents who are farmers, 50% who are marketers properly sort onions prior to storage.

The farmers and marketers interviewed revealed that floor storage on dry soil majorly sandy soil in an open room is employed for onion storage in Zaria as shown in Plate 1

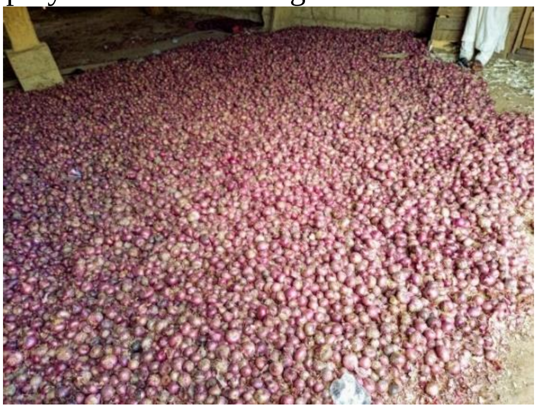

Plate 1: Floor Storage of Onions practised in Sabon Gari market, Zaria, Kaduna State.

Onions are loaded on the floor without proper grading and sorting. Basically, this storage method is accompanied with a lot of disadvantages such as less ventilation for relatively smaller sizes of onion bulbs, less bottom ventilation, pest infestation, and easy transfer of bulb diseases which bring about a lot of storage losses as reported by Deka *et. al.* (1995).

CONCLUSION

The following conclusion were arrived at after this research work:

i. Onions are packaged in jute gunny bags, polythene bags and baskets of different sizes by farmers and marketers
ii. Onions are handled and transported in big trucks, lorries, small trucks, cars, motorcycles and wheelbarrow
iii. Onions are not properly sorted and cured prior to storage
iv. Sandy soil floor storage in open rooms were predominantly used as the common storage practice in Zaria.

RECOMMENDATION
The following recommendations were proffered:

i. Better packaging material should be employed for onion packaging.
ii. Handling and transporting of onions should be done with care to prevent mechanical damage to the bulb.
iii. Proper sorting and curing of onions should be carried out prior to storage.
iv. Better storage methods should be researched upon.

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APPENDICES

APPENDIX A-1: Questions asked from the marketers and farmers

1. How are Onions packaged in Sabon Gari Market Zaria?
2. How are Onions handled and Transported to and within the market?
3. Are Onions Sorted and Cured prior to Storage?
4. What is the predominant onion storage practice or method used within the market?

APPENDIX B-1: Measuring a *Solo* of onion with the baykon BX21 Scale

Economics Of Cocoyam Production Among Rural Households In Giwa Local Government Area Of Kaduna State

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ABSTRACT

The study analyzed economics of cocoyam production among rural households in Giwa Local Government Area of Kaduna State. Purposive sampling was used to select one hundred and twenty households and they were interviewed through the use of questionnaire. Data collected were analyzed using descriptive statistics, budgetary analysis and production function. The results in the budgetary analysis indicated that the average rate of (return per Naira invested) was 1.32. This indicates that for every ₦1 invested in cocoyam production in the study area a profit of 32kobo was made, for the production function education, household size and farming experience were significant at 1% level of probability and influenced cocoyam production among the rural households in the study area. That is 1.285,0.2874 and 2.583 unit increase in each of these that is education, household size and farming experience will bring about one unit increase respectively in the output, the business is worth investing in because it is profitable. The problem of lack of chemicals was the most severe constraint of the cocoyam farmers with 24.16% of the respondents attesting to this fact while about 18.39% of the respondents had the problem of lack fertilizer to improve their production. Therefore, it is recommended that agricultural inputs such as fertilizer should be subsidized and made available to farmers at the right time, for the farmers to improve their production and increase their yield in the study area. ii. Young farmers should be encouraged to remain in farming by providing different avenues to enlighten them on the benefits in farming cocoyam, iii. Inputs like chemicals should be provided for farmers or alternatives to be able to protect their crops from diseases and Government should educate the public on the high nutritional value in cocoyam, so as to encourage more farmers to be involved in its production.

Keywords: cocoyam, production, rural, households

INTRODUCTION

Root and tuber crops which are among the most important groups of staple foods in many tropical African countries Osagie, (1998) constitute the largest source of calories for the Nigeria population (Olaniyan *et al*, 2011). Cassava (Manihot esculenta) is the most important of these crops in terms of total production, followed by yam (Dioscorea spp), cocoyam (Colocasia spp and Xanthosoma spp) and sweet potato (Ipomoea batatas) (Olaniyan *et al*, 2011). The main root and tuber crops produced in Africa are: Cassava (Manihot esculenta) 53% of the world production, (Discorea spp) yam 96%, sweet potatoes (Ipomoea batatas L.) 70%, potatoes (Sotanum spp) 4% and other root crops Colocasia spp and Xanthosoma sagittifolium) 70%. Root and tubers are generally grown in countries located in the sub Saharan zones, notably in Nigeria, Ghana, Cote d' voire, Nigeria, Benin, Cameroun, Central African Republic, D.R.C, Tanzania, Mozambique, Angola, Uganda, Malawi, Madagascar and Rwanda. Nigeria is the largest producer of taro and cocoyam which makes up 35%, followed by Ghana 14%, Cameroon 5% and Cote d'voire 3%. The other countries in Africa produce 43% of the total 27,900.00 hectares of land out of the total available land under cocoyam production. Total production of root and tuber in sub-Saharan Africa was estimated as 254million tonnes per annum in 2012 (FAOSAT, 2013). Evidence abound that root and tuber crops are efficient sources of low-cost calories because of their adaptability to wide range of ecologies. Similarly, the rural poor in some African countries Aliyu, (2000), Nigeria inclusive obtain about 65-75% of their daily food energy from root and tuber crops. Scott *et al* (2000) and Chandara (2003), described root and tuber crops as crops that describe particular attention because many developing world's poorest and most food insecure households including Nigeria look at these crops as a contributory, if not the principal source of food nutrition and income. Cocoyam (Colocasia spp and Xathosomas spp) is grown in the tropical and subtropical regions of the world particularly in Africa for human consumption, animal feed and cash income for both farmers and traders (Onwueme and Charles, 1994). In Nigeria, it is regarded as a major crop especially in female headed household. The bulk of production of cocoyam is in the South East. Cocoyam leaves are used for making soup in various parts of the world. Cocoyam belongs to the family of Arcaceae. Cocoyam root and tuber crops are well known for their high nutritional content. It is an avoid because it is grown mainly for its edible germs, however their leaves can also be used for both medicinal and culinary purpose. It is mostly cultivated in countries like Nigeria, Asia, Pacific Island, Ghana and due to its high importance. Cocoyam (Colocasia esculenta and xanthosoma mafara. (L) are important carbohydrate staple food, particularly in the southern and middle belt areas of Nigeria (Asumugha *et al*, 2002). Nutritionally cocoyam is superior to cassava and yam in the possession of higher protein, mineral and vitamin contents in addition to having more digestible starch. Cocoyam which ranks third in importance and extent of production after yam and cassava is of major economic value in Nigeria (Udealor *et al*, 1996). It is highly recommended for diabetic patients; the aged, children with allergy and for other persons with intestinal disorders, boiled cocoyam peels, cut up, dried for some days and stored or milled into flour. The flour can be used for soup, biscuits, bread and pudding for beverages. The peels can also be utilized as feed for ruminants. The surplus of the product is supplied to the market in the rapidly growing urban centers. Ezenwa, (2010) observed that there has been a decline in the yield of cocoyam in the past few years. As population pressure on land continues to increase, the importance of cocoyam in land continues to increase, the importance of cocoyam in ensuring household food security should be given adequate recognition. Although presently yield is still below expectation which could be attributed to many factors such as climate variation, drought poor cultural practice among cocoyam grower, pest and disease infestations.

The Objectives of the Study Identify the inputs and output of cocoyam production in the study area, determine the profitability of cocoyam production in the study area, estimate the socio-economic factors influencing the profitability of cocoyam production in the study area and identify the constraints faced by the respondents in cocoyam production in the study area.

METHODOLOGY

Study Area

The study was carried out in Giwa Local government area of Kaduna State. The study area plays a significant role in agricultural production in Kaduna State. It is located on Latitude $11^0$12' North and Longitude $7^0$34' East. Giwa Local Government area of Kaduna State is bounded in the North by Funtua local Government area of Katsina State, in the west by Birni Gwari and Igabi Local Government area of Kaduna State also bounded in the west by Faskari Local government area of Kaduna State. In the east Giwa is bounded with Danja Local Government, and has a population of 300,200 persons mainly Hausa/Fulani with few other minor ethnic group like maguza was (NPC, 2006). There are eleven (11) districts in Giwa namely; Giwa, Gahara, Yakawada, Shika, Kaya, Patika, Tsibiri, Damawaye, Karakan, Kakangi, and Kidandan. The area is characterized by alternating dry and wet season with a mean annual rain fall of between 1000-1350mm. The duration in the area is about five months beginning from May and ends in October. The rainfall pattern in the area is therefore suitable for food crop production. The predominant occupation of the people in the Local Government Area is farming. In the Local Government Area crops grown include: Cocoyam, yam, Cassava, maize, Cowpea, sorghum, pepper, tomatoes, Groundnut, carrot, and potatoes while livestock such as cattle, sheep and chickens, guinea fowl are also fund in the area.

Sampling Techniques

Out of the eleven districts (11) of Giwa LGA, twelve (12) villages namely; Doka, Gangara, Patika, Tunburku, Tsibiri, Maguzawa, Yakawada, Kidandan, Kaya, Fatika, Galadimawa and Giginya, was randomly selected from the districts in study area. Ten (10) cocoyam farmers each from each of the villages were purposively selected to administer the questionnaires to them; this gave a total of one hundred and twenty (120) questionnaires respectively.

Data Collection

Primary data was used for the study. The primary data was collected by using well structured questionnaire and interview schedule.

Analytical Techniques

The following tools of analysis was used to achieve the stated objectives of the study. Descriptive statistics, budgetary Analysis and Production Function

Budgetary Analysis

This was used to analyse the cost and returns in cocoyam production as well as estimate the profit of the venture; as adopted by Akinpele and Ogbonna (2005)

Theoretically, the definitional equation is expressed as;

NFI = GFI -TC (TVC + TFC)

NFI = Net Farm Income, TVC = Total Variable Cost, TFC = Total Fixed Cost, TC = Total Cost

R/N = Return per naira.

Production Function

Production function was used to determine the physical relationship between the inputs and output of production to achieve objective (ii). It was expressed as:

$$Y = F(X1, X2, X3, X4, X5, X6 \ldots \ldots \ldots \ldots \ldots .. e)$$

Where,

Y= Output (N), X_1= Age (years), X_2= marital status (years), X_3= education(years)

X_4= Household size (number), X_5= farming experience, X_6= cooperative, b_1- b_6 = Regression Coefficients, b_0 = constant and e = error term

RESULTS AND DISCUSSION

Inputs in Cocoyam Production

Table 1 below show the highest value and lowest value of the inputs in cocoyam production in the study area fertilizer had the high value of ₦98,000 among the farmers who farm more than 5 hectare of land, why the lower price of ₦2000 are back yard farmers around the house gardens. Chemicals had ₦5,000 higher value and low value of ₦3000, seed have high value of ₦24,000 and low value of ₦600 and family labour highest value is ₦87,200 and low value of ₦1,200. The higher value of cocoyam production in the study area gives more outputs than the lowest value of those who farm for house consumption.

Table 1: Summary of Inputs used in Cocoyam Production in the study area.

	Fertilizer	Chemical	Seed	Family labour
Maximum	₦98,000	₦75,000	₦24,000	₦87,200
Minimum	₦2,000	₦3,000	₦600	₦1,200

Profitability of Cocoyam Production in the Study Area

The result in the Table 2 above revealed that the farmers used more cocoyam seed in the study area for the production of cocoyam. The quantity of seed used in was ₦17,234.71. The farmers in the study area mainly used unimproved seeds for their production. This was followed by the quantity of fertilizer which was ₦16973.13 which was used with the average market price of ₦7,500 per 50kg bag for the production of cocoyam. Also the labour costs consist of land preparation, planting, weeding, fertilizer application and harvesting. The family labour was computed on the basis of shortage of manpower. The wage rate varied according to farm operation to be performed. The average labour cost per hectare was ₦13,706.67 while the total cost of renting land and cost of depreciation of tools incurred on cocoyam production was ₦2500 and ₦1100 respectively and this constituted the total fixed cost. The result in the Table revealed that the total revenue (TR) was ₦77,208.34, while the total cost (TVC+TFC) was ₦58,593.03. the net farm income was therefore ₦18,615.31. The average rate of (return per Naira invested) was 1.32. This indicates that for every ₦1 invested in cocoyam production in the study area a profit of 32kobo was made. Thus, it could be concluded that cocoyam production in the study area though on a small scale, was economically viable. The finding is similar to that of Abdulrahman *et al* (2015) who observed that cocoyam production is profitable by reforming ₦1.69 to every ₦1.00 spent.

Table 2: Average Cost and return per hectare of Cocoyam Production

Variables	Values	% Contribution
Gross farm income	77,208.34	
Total cost (TVC + TFC)		
Inputs		
a. Seed	17,234.71	29.41
b. Fertilizer	16,973.13	28.97
c. Chemical	70,78.52	12.08
d. Labour	13,706.67	23.39
Total variable cost (a+b+c+d)	54,993.03	
a. Cost of renting land	2,500	4.27
b. Depreciation of tools hoe and cutlass	1,100	1.88
Total fixed cost = (a+b)	3,600	6.14
Total cost(TVC+TC)	58,593.03	
Net farm income = (NFI) = (GFI – TC)	18,615.31	
Return per Naira invested (GFI / TC)	1.32	

Multiple regression analysis of cocoyam production in the study area

The results of the analysis shows that the linear function had the best fit and was therefore chosen as the lead equation. This was due to the highest R^2 value of 0.521. This implies that 52% variability was explained by the independent variable while the remaining 48% was due to error term. The result further showed that the production of the cocoyam farmer was positively influenced by education, household size and farming experience. The result of this study has clearly shown that opportunities exist in cocoyam production. The result showed that there is a significant and negative relationship between years of experience production at 1% level of significance. That implies that cocoyam farmers with more years of experience exhibited significantly more production than farmers with less years of experience. This could probably be explained by the fact that farmers employ their years of experience over time as an opportunity to enhanced more production. This finding is consistent with the result in Table 3 also showed that there is a significant and positive relationship between education and production at 1% level of significance. This implies that cocoyam farmers with more education or who spent more years in school) exhibited significantly more production than farmers with less education, household size was also a very strong factor that influenced cocoyam production because the more the household, the more persons available in the form of family labour to help the farmers in his production.

Table 3: Multiple regression for respondents in the study area.

Variables	Parameters	Coefficients	St. error	T-Value
Constant		6.5642	0.839	0.403
Age	X^1	1.1018	1.491	0.139
Marital status	X^2	3.025	-0.174	0.862
Education	X^3	0.1999	1.285	0.000*
Household size	X^4	0.1548	0.2874	0.000*
Farm experience	X^5	0.9827	-2.583	0.000*
Cooperative	X^6	0.2289	-0.775	0.440
R=0.543				
R2=0.521				
Adjusted R^2 = 0.57				
Total observation = 120				

Constraints to Cocoyam production in the study area.

Tables 4 showed the problems faced by the cocoyam farmers in the study area. The problem of lack of chemicals was the most severe constraint of the cocoyam farmers with 24.16% of the respondents attesting to this fact. About 18.39% of the respondents had the problem of lack fertilizer to improve their production. According to the farmers fertilizer is made available when farmers are far into the production period. 15% of the respondents also reported lack of water and diseases respectively as the third major constraint they faced. About 10.84% of the respondents lacked capital to expand their production. Farmers also said that land size is not enough for them farming which caused shortage in their production and ranked as the fifth problem by 5.84%, lack of modern equipment was 4.16% which was revealed to boast their production was not available and making them to use crude tools such as hoe and cutlasses. Erosion problem in the study area made up 4.16% which washes the top soil making their production to be low. During the harvesting period lack of storage facilities made up 2.5% which makes the farmers to loose their products in cocoyam production. Although the last two constraints mentioned above were minor constraints faced by the farmers in the study area.

Table 4: Constraints of Cocoyam Farmers in the study area.

Constraint	Frequency	Percentage (%)
Lack of chemicals	29	24.16
Fertilizer	27	18.34
Diseases	18	15.00

Lack of water	18	15.00
Inadequate capital	13	10.84
Insufficient land	7	5.84
Lack of modern equipment	5	4.16
Erosion	5	4.16
Storage	3	2.5
Total	120	100

CONCLUSION

The findings of the study revealed that cocoyam production in the study area is profitable so that for every ₦l invested in cocoyam production in the study area a profit of 32 kobo was made. Also education, household size and farming experience were factors which influenced cocoyam production. The major constraints militating against cocoyam production identified were high cost of fertilizer, high cost of chemicals, lack of storage facilities and unavailability of land to increase their production.

RECOMMENDATIONS

i.Agricultural inputs such as fertilizer should be subsidized and made available to farmers at the right time, for the farmers to improve their production and increase their yield in the study area.ii. Young farmers should be encouraged to remain in farming by providing different avenues to enlighten them on the benefits in farming cocoyam, iii. Inputs like chemicals should be provided for farmers or alternatives to be able to protect their crops from diseases and Government should educate the public on the high nutritional value in cocoyam, so as to encourage more farmers to be involved in its production.

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Economic Analysis of Cassava Production in Afikpo North Local Government Area of Ebonyi State, Nigeria.

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ABSTRACT

The study analyzed the economics of cassava production in Afikpo North LGA of Ebonyi State, Nigeria using 150 respondents selected through multistage and simple random sampling techniques. Data were collected with the aid of well structured questionnaire administered in form of interview schedule. Data collected were analyzed using descriptive statistics and budgetary techniques tools such as gross margin analysis, net farm income and Benefit-Cost Ratio. The result shows that majority of the respondents (65.33%) are females and 74.66% falls between the productive, active and energetic working age range of 31 – 60 years while 73.33% of the respondents are married. Furthermore, about 62.66% attended primary school and 84.65% have extensive household size of between 4 – 12. The result further reveals that farm size of cassava farmers in the area varied, 89.98% of the respondents fall between 0.6 – 2.0 hectares and a greater number of them (85%) practice multiple cropping system of cassava production while majority (93.66%) of the farmers have farming experience of above 6 years. The result of the constraints faced by cassava farmers in order of their severity include lack of storage facilities, low income, poor transportation system, land scarcity, high cost of agro-chemicals, inadequate capital, and lack of access to credit among others. The result of the cost and returns analysis using gross margin, net farm income and benefit-cost ratio reveals gross margin of N108, 050.00; net farm income of N96,050.00 per hectare obtained by cassava farmer and benefit-cost ratio of 1.67 indicating for every one naira invested in cassava farming, an additional N1.67kobo was realized. It was concluded that cassava production in the study area was profitable but with a lot of constraints. Therefore, the Government should assist in providing storage facilities and provide input incentives to encourage increased productivity and income to cassava farmers. Also, agricultural extension agents should be deployed to the area to facilitate the adoption of improved varieties and some other new technologies to boost cassava production in the locality.

KEY WORDS: Economic analysis, Cassava Production, Socio-economic variables, Gross margin, Constraints.

INTRODUCTION

Cassava (*manihot esculenta*), also called manioc or yuca, a tuberous edible plant of the spurge family (Euphorbiaceae) is said to have been introduced in central Africa from Brazil, South America in the sixteen century by the early Portuguese explorers. Cassava is among the main vitality agricultural produce for many African citizens. Empirical studies affirmed that in the 1980's, after rice, maize, and sugarcane, cassava was the fourth most important dietary source of calories produced within the tropics and probably still holds that position due to its great importance in the diet of Africans (Cock, 2011; Afedraru and Lominda, 2019) . Cassava flour, breads, tapioca, a laundry starch, and alcoholic beverages are derived from cassava (Esheye, 2019). The benefits of cassava to the Nigeria populace cannot be over emphasized. Apart from being a staple food in Nigeria, it is a source of energy, creates jobs, boost food security and national income (Ezedinma *et al* 2007 and IITA, 2017). In 2020, global production of cassava root was 303 million tonnes, with Nigeria as the world's largest producer, producing 20% of the world total; however, other major growers were Democratic Republic of the Congo and Thailand (FAOSTAT, 2019). Cassava was introduced in southern Nigeria by Portuguese explorers in the sixteenth century (Adeniji, et al, 2005). Cassava is a major economic crop in Nigeria, because of its tolerance of poor soils and low rainfall. Cassava acts as a famine reserve and offers flexibility to resource-poor farmers because it serves as either subsistence or a cash crop (Stone, 2002).

Although Nigeria is the largest producer of cassava in the world, the country is not an active participant in the international market on cassava when compared to Brazil, Indonesia and Thailand with lesser production output (Agom, et al, 2012) because 90% of the total cassava produced in Nigeria is for consumption, while only as low as 10% is for industrial use (Awoyinka, 2009). This study, therefore, intends to analyse the cost and returns of cassava production in Afikpo North Local Government Area of Ebonyi State, Nigeria as well as assess the current challenges of cassava production in the study area so as to proffer solutions to increase productivity and income. Specifically, the study described the socio-economic characteristics of cassava farmers; estimated the cost and returns of cassava production; and identified the challenges faced by cassava farmers in the study area.

METHODOLOGY

Study Area

The study area was Afikpo North Local Government Area (ANLGA), Ebonyi State, Nigeria. ANLGA is situated in the southern part of Ebonyi State. Afikpo is the second largest city in Ebonyi state. Its headquarters is in the town of Ehugbo and its important communities includes; Amata, Unwana, Itim, Ohaisu, Nkpoghoro, Ugwuegu/Amaizu, Ozziza, Amasiri and Ibii/Akpoha. It has an area of $240km^2$ in size with a population of 881,611 according Nigerian 2021 census. ANLGA has a tropical climate that is characterized by high temperature all year round. The area enjoys two distinct seasons, which are rainy season (April – October) and dry season (November – March). The climate supports the growing of the following crops, yam, cassava, oil palm, cashew, cocoa, vegetables, maize and rice

Sampling Procedure

The multi-stage and simple random sampling techniques were used in drawing samples from the study area. The first stage was a purposive selection of five (5) villages majorly known for its high production of cassava, namely; Ugwuegu, Amaizu, Nkpoghoro, Ohaisu and Ozziza, out of the nine villages in the Local Government Area. The second stage involved simple random selection of twenty (30) cassava farmers from each of the selected communities giving a sample size of 150 respondents for the study area. Structured questionnaire and oral interview schedule was used to collect data. Descriptive statistics such as percentages and frequencies as well as mean score likert scale were used to describe the socio-economic characteristic of the respondents and constraints faced by cassava farmers respectively in the study area. Budgetary techniques were used to estimate cost and returns on cassava production in the study area.

Data Analysis

Budgetary technique analysis such as gross margin, net farm income and benefit-cost ratio were used to estimate the costs and returns of cassava production in the study area. According to Okon and Okorji (2014), farm budgetary analysis enables the farmer estimate his total costs as well as the total revenue accrued to his enterprise within a farming season. Gross margin analysis (GMA) is a simple, reliable tool to assess the financial performance of an enterprise. Thus, gross margin (GM) is the difference between total revenue (TR) and the total variable cost (TVC) (Olukosi and Erhabor, 1998)

The gross margin is calculated as follows;

GM = TR –TVC

Where; GM = Gross Margin from cassava production (₦)

TR = Total Revenue from cassava production (₦)

TVC = Total variable cost from cassava production (₦)

While the net farm income (NFI) is calculated as follows:

NFI = TR – TC

The total cost of production (TC) is defined as TC = TVC + TFC

TFC = Total fixed cost (rent on land) (₦)

Also, benefit-cost ratio (BCR) is calculated as follows:

BCR = TR/TC

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents:

The socio-economic variables of cassava farmers may influence their decision regarding scale, enterprise diversification and production processes. The result of the socio-economic characteristics of the respondents is presented in table 1 below.

The result shows that majority of the respondents are females (65.33 %.) while the age range of active farmers is between 21-61 years which constitute 83.99% of the cassava farmers in the area with a mean of 45 years. The result further shows that 73.33% of the respondents are married. Furthermore, about 62.66% attended primary school and most of the respondents (84.65%) have extensive household size of between 4 – 12 with a mean family size of 9, indicating enough family labour and less been spent on hired labour. The result further reveals that farm size of cassava farmers in the area varied, 89.98% of the respondents fall between 0.6 – 2.0 hectares, the mean farm size being 1.23 hectares implying that farmers operate on a small farm holding of less than 1.5 hectares this is because they acquire their land predominantly through family land (Nandi, et al, 2011). Given the small farm size, 85% engage in multiple cropping system of cassava production in order to maximize the farm land. Majority (93.66%) of the farmers have farming experience of above 6 years implying that farming is their major occupation and means of livelihood.

Table 1: The distribution of socio-economic characteristics of respondents in the study area.

S/N	Variables	Frequency	Percentage	Mean
1.	**Gender:**			
	Female	98	65.33	
	Male	52	34.66	
2.	**Age:**			

	≤ 20	7	4.66	
	21 – 30	14	9.33	
	31 – 40	30	20.0	
	41 – 50	43	28.66	44.8
	51 - 60	39	26.0	
	≥ 61	17	11.33	
3.	**Marital Status:**			
	Married	113	73.33	
	Single	5	3.33	
	Divorced	20	13.33	
	Widowed/widower	12	8.0	
4.	**Educational Level:**			
	No Formal Education	40	26.66	
	Primary Education	94	62.66	
	Secondary Education	11	7.33	
	Tertiary Education	5	3.33	
5.	**Household Size:**			
	≤ 3	8	5.33	
	4 – 6	28	18.66	
	7 – 9	31	20.66	8.9
	10 – 12	68	45.33	
	≥ 12	15	10.0	
6.	**Farm Size:**			
	≤ 0.5	11	7.33	
	0.6 – 1.0	37	24.66	
	1.1 – 1.5	70	46.66	1.23
	1.6 – 2.0	28	18.66	
	> 2.0	4	2.66	
7.	**Primary Occupation:**			
	Farming	89	59.30	
	Trading	23	15.0	
	Civil Servant	18	12.0	
	Artisans	20	13.33	
8.	**Cropping System:**			
	Sole	8	5.33	
	Multiple	128	85.0	
	Both	14	9.33	
9.	**Farming Experience:**			
	≤ 5	9	6.0	
	6 – 10	19	12.66	
	11- 15	24	16.0	15.38
	16 – 20	81	54.0	
	> 20	17	11.33	

Source: Field Survey, 2021

Major constraints faced by respondents in the area:

During the field work, the respondents were asked to indicate the extent to which some hypothesized constraints were binding to them. This was done using a four point likert scale namely, strongly agreed = 4, agreed =3, disagreed = 2 and strongly disagreed = 1 with a mean likert scale of 2.5. The table 2 below represents the result of constraints faced by farmers in order of their severity. The weighted mean of 2.5 was used as the critical value for comparing the order of severity. Result shows that all the listed constraints were considered as binding. At a mean of 3.6, lack of storage facilities is the most critical of all the constraints, followed by low income with a mean of 3.54, and poor transportation system with a mean of 3.47. Others are land scarcity (3.46), high cost of agro-chemical (3.36), inadequate capital (3.30), and lack of access to credit (3.28) among others. The result obtained in this study is consistent with that of Kuye (2015), who reported high cost of inputs as the constraints faced during cassava production in South South Nigeria. Also the result of this study agrees with findings of Itam, Ajah and Agbachom (2014) who conducted a similar study in Akpabuyo Local Government Area of Cross River State, Nigeria. However, constraints with less impact includes lack of processing facilities (2.80), low price of finished product (2.63), and cost of planting materials (2.58) while pests and diseases attack (2.1) was considered as not been a constraint. These constraints identified often lead to losses in terms of crop productivity, extra financial and material cost as well as have negative implications on the net returns of cassava eEnterprise. The findings of this study further confirm the report of Esheya (2019) in Ohaukwu local government area of Ebonyi State.

Table 2: Major Constraints Faced by Cassava Farmers in the Study Area (N = 150)

S/N	Constraints	Strongly Agreed	Agreed	Dis-agreed	Strongly Disagreed	Mean	Rank	Decision
1.	Land scarcity	95(380)	35(105)	15(30)	5(5)	3.46***	4rd	Accept
2.	Cost of planting material	6(240)	80(240)	59(118)	5(5)	2.58*	12th	Accept
3.	Lack of processing facilities	30(120)	77(231)	26(52)	17(17)	2.80*	10th	Accept
4.	Lack of improved cassava varieties	56(224)	54(162)	30(60)	10(10)	3.04**	9th	Accept
5.	Inadequate capital	78(312)	56(168)	16(32)	-	3.30***	6st	Accept
6.	Scarcity of Labour	54(216)	71(213)	16(32)	9(9)	3.13**	8th	Accept
7.	Lack of access to credit	81(324)	41(123)	18(36)	10(10)	3.28***	7nd	Accept
8.	Low income	88(352)	56(168)	6(12)	-	3.54***	2nd	Accept
9.	Low price of finished product	30(120)	60(180)	35(70)	25(25)	2.63**	11th	Accept
10.	Pest and disease attack	25(100)	5(15)	80(160)	40(40)	2.1**	13th	Reject
11.	High cost of agro-chemicals	92(368)	29(87)	21(42)	8(8)	3.36***	5th	Accept
12.	Lack of storage facilities	105(420)	30(90)	15(30)	-	3.60***	1st	Accept
13.	Poor transportation sysstem	90(360)	43(129)	15(30)	2(2)	3.47***	3rd	Accept

Source: Field Survey Data, 2022.

Cost and Returns of Cassava Production in Afikpo North LGA

The summary of costs and returns to cassava farmers in Afikpo LGA, Ebonyi State is presented in Table 3 below. The profitability of cassava production was determined using budgetary analysis such as gross margin, net farm income and benefit-cost ratio to estimate the cost and return. Gross margin is the difference between the Total Revenue and Total Variable Cost while Net Farm Income is the difference between the Total Revenue and the Total Cost accrued within a specific production period. Results show that at ₦131,900.00, the total variable cost (TVC) was higher than the total fixed cost (TFC) of ₦12,000.00 per hectare of cassava production in the study area. The result further showed that the total variable cost of ₦131,900.00 accounted for 92% of the total cost while the total fixed cost component of ₦12,000.00 accounted for 8% of the total cost. The total cost (TC) per hectare of **₦143,900.00** was incurred in cassava production with a total revenue of ₦239,950.00 showing a net farm income (NFI) of **₦96,050.00.** This result shows that cassava production in the study area was profitable which agreed with the findings of Esheya (2019) who reported a net farm income of ₦89,734.00 per hectare of cassava production in Ohaukwu Local Government Area which is also in Ebonyi State. The result also shows that for every one naira investment in cassava production in the study area 67 kobo is earned which shows a benefit-cost ratio of 1.67. This is also in support of Sanusi et.al (2020); Toluwase and Abdul-raheem (2013) who asserted that cassava production is a profitable venture and that an economic venture is considered viable if it has a positive gross margin and benefit-cost ratio greater than one. The results therefore suggest that cassava production in the study area is a profitable venture and a boost to food security and rural poverty alleviation.

Table 3: Average Cost and Returns of Cassava Production per hectare per Year in Afikpo North L.G.A

Variable Items	Unit	Quantity	Unit price (₦)	Cost (₦)	% of total cost (₦)
A. Variable cost					
Cassava cutting	Bundles	30	650	19,500.00	
Labour	Mandays			44,800.00	
Fertilizer	50Kg/bag	5 bags	8,000.00	40,000.00	
Herbicides	Litres	3	1,800	5,400.00	
Pesticides	Litres	3.5	1,800	6,300.00	
Other major expenses including transportation	-			15,900.00	
Total variable cost				**131,900.00**	91.66
B. Fixed cost					
Cultivated land rent	Hectare	1	12,000	12,000.00	8.33
Total cost				**143,900.00**	

C. Revenue				
Cassava stem	Bundles	115	250	28,750.00
Cassava tubers	Kg	11930	15	178,500.00
Quantity consumed	kg	2150	15	32,250.00
Total Revenue				**239,950.00**
Gross Margin/year				**108,050.00**
Net Farm Income				**96,050.00**
Cost- Benefit Ratio/ Return on Investment				**1.67**

Source: Field Survey Data, 2022.

CONCLUSION AND RECOMMENDATION

Based on the findings from the study, it can be concluded that cassava farming enterprise is a profitable business venture with an average gross margin of N108, 050.00 and Net Farm income of N96, 050.00 and Benefit-Cost Ratio of 1.67 per hectare, meaning that for every one naira invested in the production, there is a profit of N1.67 kobo obtained. This shows that cassava production in Afikpo North Local Government Area of Ebonyi State, Nigeria is economically viable and lucrative. Although cassava production in the study area was profitable but lack of storage facilities, low income, poor transportation system, land scarcity, high cost of agro-chemicals, inadequate capital, poor access to credit, scarcity of labour, lack of improved cassava varieties, lack of processing facilities, and low price of finished cassava products were the severe constraint faced by cassava farmers in the study area. It is therefore necessary that farmers should be encouraged to invest more on cassava production in the area by government assisting to alleviate most these constraints faced by cassava farmers in the area. Thus, government should assist in providing modern storage facilities and provide input incentives such as credit facilities, agro-chemicals and improved cassava varieties at a subsidized rate. Agricultural extension agents should be deployed to the area to facilitate the adoption of improved varieties and some other new technologies to boost cassava production in the locality. Generally, the Government should encourage the youths who are sources of labour and more active in cassava production by giving them financial grants and/credit. This will discourage rural-urban migration for white-collar jobs.

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Covid-19 Policies Effects on Cassava Production in Khana Local Government Area, Rivers State, Nigeria

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ABSTRACT

The study analyzed the COVID-19 policies effects on cassava production in Khana Local Government Area, Rivers State, Nigeria. The specific objectives were to describe the socio-economic characteristics of cassava farmers in the study area, determine COVID-19 policies effects on cassava production, and identify challenges to efficient cassava production in the study area. Data for the study were collected via the use of questionnaires from 120 respondents, and were analyzed using descriptive statistics. The result showed that most of the respondents were male 57.50% while 42.50% were female, 36.67% were married. about 35.00% of the respondents were within the age of 31-40 years. The study concluded that COVID-19 pandemic lockdown policies had devastating effects on cassava production. The study recommended that proactive government intervention policies to stimulate economic growth that will generate positive effects on the local players in cassava farming sub-sector of the economy be put in place during post COVID-19 pandemic era.

KEYWORDS: Covid-19, Pandemic, Lockdown, Effect, Cassava, Production.

INTRODUCTION:

Cassava (Manihot spp) a perennial woody shrub crop with an edible root, was first cultivated in South America and introduced to Nigeria in the Sixteenth century (Adenji et al., 2005).The majority of cassava farmers cultivate small farm areas which are not conducive or economical for mechanization yet, Abass et al. (2014) have argued that without mechanization, using improved inputs alone will not sufficiently boost cassava production in Nigeria, Cassava is one of the fastest expanding staple food crops in cassava consuming countries and has continued to gain prominence among farmers, while the industrial demand is also rising consistently (Food and Agricultural Organization FAO, 2018).

Covid-19 pandemic far more than a health crisis has affected societies and economics (IFAD, 2020). It has threatened people in every country through devastating lives and livelihoods. Lederer (2020) tagged it as the most challenging crises since world war 11, which could bring a recession. It has disrupted public health in an unprecedented manner and thus exposed the agricultural value chain to economic uncertainties (Lederer, 2020). The use of public measures like physical distancing, household isolation, massive lockdown, and border closures to slow the spread of the new virus is no doubt working, but not without delivering a significant fall in economic activity. The demand and supply of goods had been in shocks (FAO, 2020b).

It is, therefore, essential to examine the COVID-19 policies effects on cassava production in Khana Local Government Area of Rivers State, Nigeria. The specific objectives of this study were to: describe the socio-economic characteristics of cassava farmers in the study area; determine the effects of Covid-19 policies on cassava production; and identify challenges to efficient cassava production in the study area.

METHODOLOGY

Study Area: The research work on COVID-19 policies effects on cassava production was conducted in Khana Local Government Area of Rivers State. Its administrative seat (headquarter) is in Bori. It has a land area of 560km^2 and an average temperature of 25^{0}c. The postal code is 504 with a coordinates of 4.6476^{0}N and 7.3949^{0}E. Their major occupations are: farming, fishing, and trading. Their estimated population was about 294,217 in 2006 census (NPC, 2006)**Sampling Procedure and Sample Size**

Multi-stage sampling procedure was adopted to select ten farming communities that are preponderance cassava producers. They are kereken Bo-ue, Sogho, Bianu, Zaakpon, Kaa, Kaani, Kor, Gwara, Nwiiyaakara and Lueku. The next stage was the random selection of twelve cassava farmers from each of the communities already selected, giving a total of one hundred and twenty respondents that were used for the study.

Data Collection; Primary source of data was used via the instrument of structured questionnaire.

Data Analysis; Data collected were analyzed using descriptive statistics such as mean and percentages.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents

Table 1 indicates the Socio-Economic Characteristics of the Respondents.

Characteristics	Category	Frequency	Percentage	Mean
Age (years)	21-30	13	10.83	
	31-40	42	35.00	
	41-50	30	25.00	45.5
	51-60	27	22.50	
	Above 60	8	6.67	
Gender	Male	69	57.50	
	Female	51	42.50	
Marital Status	Single	36	30.00	
	Married	44	36.67	
	Divorced	17	14.17	
	Widow	23	19.16	
Household Size	1-5	68	56.67	6
	6-10	52	43.33	
Educational Qualification	None	12	10.00	
	Primary	28	23.33	
	Secondary	33	27.50	
	NCE	16	13.33	

	Vocational	8	6.67	
	Adult Education	5	4.17	
	HND/Degree	18	15.00	
Farming Experience (yrs)	1-5	26	26.67	15.6
	6-10	30	25.00	
	11-15	35	29.17	
	16-20	18	15.00	
	Above 20	11	9.16	

Source: Field Survey, 2022.

Age of the Respondents

The respondents' age ranged from 21-69 years. The highest age range of the respondents was found to be within 31-40 years of age, representing 35.00%, closely followed by the age range of 41-50years representing 25.00%, while 22.50% is within 51-59 years. The respondents within the age range of 21-30years accounted for 10.83%, while those above 60 years of age represent 6.67%, the average age mean of the respondents was 45.5years.

Sex of the Respondents

Furthermore, 57.50% of the respondents were male, while 42.50% were female. This shows the dominance of male in cassava production.

Marital Status of the Respondents

The results on marital status showed that 36.67% of the respondents were married 30.00% were single, 19.16% were widowed and 14.17% were divorced.

Household Size of the Respondents

The result on household size indicated that 56.67% of the respondents had up to 5 persons, while 43.33% had between 6-10 persons in their household. The average family size was six persons. This implies that the household size of the respondents were relatively large. Thus, this may positively influence farming activities. This agreed with the earlier findings of Omoare et al.(2014) that large family size is an indicator of labour availability for various farming activities.

Educational Qualification of the Respondents

The respondents attained various forms of education. Although 10.00% had no formal education, 23.33% had a primary school, 27.50% had secondary education, 13.33% had NCE qualification, 6.67% had no vocational training, 4.17% had adult education, while 15.00% had higher diploma or degree. It was observed that 90.00% had formal education. The high level of education among the respondents, according to Oyediran et al. (2015), may encourage acceptance of innovation.

Farming Experience of the Respondents

The result on farming experience indicates that 26.67% of the respondents had up to 5 years of farming experience, 25.00% had between 6-10years of experience, while 29.17% of the respondents had between 11-15years of experience. The rest 15.00% and 9.16% of the respondents had between 16-20 years and above 20 years of farming experience.

4.2 Perceived Effect of Covid-19 Lockdown policies on Cassava Production

Statements	SA	A	D	SD
COVID-19 will improve	13	17	30	60

Cassava production	(10.8)	(14.2)	(25.0)	(50.0)
COVID-19 will affect the availability of labour for land preparation	55 (45.8)	43 (35.8)	14 (11.7)	8 (6.7)
COVID-19 may affect cost of cassava production	40 (33.3)	36 (30.0)	10 (8.3)	12 (10.0)
COVID-19 may cause Cassava losses	49 (40.8)	43 (35.8)	17 (14.7)	11 (9.2)
COVID-19 will affect the Quality of produce for sale and thus impact human health	36 (30.0)	38 (31.7)	20 (16.7)	26 (21.7)
COVID-19 will affect Cassava farming activities Negatively.	57 (47.5)	44 (36.7)	10 (8.3)	9 (7.5)
Low rate of production will affect commodity prices	50 (41.7)	41 (34.2)	18 (15.0)	11 (9.2)
COVID-19 will affect sales of farm inputs, chemicals and fertilizer.	63 (52.5)	35 (29.2)	16 (13.3)	6 (5.0)

NOTE: The figures in parenthesis are in percentage
Source: Field Survey, 2022

The result presented in Table2 shows the perceived effect of COVID-19 lockdown policies on cassava production. The resultsshows that majority of the respondents (50.0%) strongly disagreed that COVID-19 lockdown will improve cassava production. The perishability or spoilage nature of crops was experienced by (40.8%) of the respondents as a result of COVID-19 lockdown policies, it affected sales of farm inputs, chemicals, and fertilizer during cropping season (52.5%). The restriction on movement and global agricultural activities affected the commodity price of farming inputs, and the low rate of production of cassava also affected the related commodity prices (41.7%). The respondents (47.5%) strongly agreed that pandemic affected cassava farming activities negatively as it alters the farming cultural practices because of the lockdown. It affect the quality of produce for sale further and thus impacted human health (31.7%), and thus affected the availability of labour for land preparation (45.8%). Finally, (33.3%) of the respondents strongly agreed that COVID-19 may affect cost of cassava production.

4.3 Constraints to Efficient Cassava Production

Table 3 shows a summary statistics of the challenges to efficient cassava production in the study area (n=120)

Challenges	Mean	Ranking	Result	Remark
Shortage of healthy and good-quality planting materials	3.93	1	>	Agreed
High incidence of pest and diseases	3.82	2	>	Agreed
Unavailability of agro-chemicals and other insecticides	3.78	4	>	Agreed
Soil erosion problem	3.61	5	>	Agreed
Soil fertility problem	3.80	3	>	Agreed
Damage by livestock	3.00	6	>	Agreed

Criterion Mean: >3.00
Source: Field Survey, 2022.

Table 3 shows that all the enlisted challenges of cassava production were experienced by the respondents in the study area. These include shortage of healthy and good-quality planting materials, high incidence of pest and diseases, unavailability of agro-chemicals and other insecticides, soil erosion problem, soil fertility problem and damage by livestock as they all had a mean value that is greater than the criterion mean (>3.00).

CONCLUSION AND RECOMMENDATION

The study examined COVID-19 policy effect on cassava production in Khana Local Government Area, Rivers State, Nigeria. The study revealed that COVID-19 pandemic and lockdown had a devastating impact on farmers and cassava production. Based on these findings, the following recommendations were made: proactive government policies to stimulate economic growth that will generate positive impact on the local players in the cassava farming sub-sector of the economy be put in place to cope with the post-pandemic effect of COVID-19.

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Moringa Oleifera-Cowpea Intercrop; Cost Benefit Analysis In Sabon-Gari Local Government Area Of Kaduna State, Nigeria

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ABSTRACT

Moringa oleifera-cowpea intercrop and its cost benefit analysis in Sabon-Gari Local Government Area of Kaduna state, Nigeria was examined in this study. 50 farmers participated in the adoption process with the aid of structured questionnaire. Result of the gross margin analysis indicated that Moringa/Cowpea intercropping is a profitable farming with a net profit of ₦65,180 which without Moringa stood at ₦27, 680 representing 57.5% rise in profit for the intercropping. The naira spent value of ₦2.20 implied that on every naira invested, the sum of ₦1.20k gain was made at 120% profit value thus Moringa/Cowpea intercrop is a highly veritable and profitable agro-business. It is quite evident that the farmers are not fully aware of the modern ways of propagation and multipurpose uses of Moringa oleifera. The need to harness the numerous uses of Moringa oleifera through research work, farmers' participation, training and retraining of both extension workers and farmers, involvement of all stakeholders is thus recommended by this study.

Keywords: Moringa, Cowpea, Intercropping, Propagation, *Moringa oleifera*

INTRODUCTION

Intercropping has been defined as the growing of two or more crops simultaneously or during parts of the component crop life cycle on the same piece of land (Alamu, 2002; Yusuf, *et al*., 2008). This farming practice is commonly used by subsistence farmers in the semi-arid areas of Africa. It provides the farmer with a variety of returns from land and labour, often increases the efficiency with which scarce resources are used, and reduces the risk of high dependency on a single crop that is susceptible to environmental and economic fluctuations. The reasons for practicing intercropping are rational; however, despite this logic, few research resources have been allocated in the past for investigating the complex interaction between crops growing on the same piece of land. This situation has existed as a consequence of the transfer of western concepts that are considered to be good farming practices and the technical problems involved in experimenting with intercropping. As a result, the biological effects of one crop on another and the economic costs and returns of intercropping have not been well understood. And yet, scientists now accept that intercropping is important to the subsistence farmer and many are convinced that research into the interactions between crops growing together must be undertaken to provide answers that will improve agricultural productivity for the subsistence farmer (Bruce, 1980). In Nigeria, income of farmers who harvest, and store cowpea fodder for sale at the peak of the dry season have been found to increase by 25% (Dugje, *et al*., 2009). Cowpea also plays an important role in providing soil nitrogen to cereal crops (such as maize, millet, and sorghum) when grown in rotation, especially in areas where poor soil fertility is a problem. It does not require a high rate of nitrogen fertilization; its roots have nodules in which soil bacteria called Rhizobia help to fix nitrogen from the air (Dugje, et al., 2009). Since Moringa does not fix nitrogen, it is expected that intercropping it with cowpea will bring about beneficial interaction. Moringa (*Moringa spp.*) is one of the world's most useful foods, medicinal and industrial plants. Fuglie, (1999); Foidl, *et al*., (2001) and Fahey, (2005) have all documented extensively the wonder plant called Moringa. It is a fast-growing tree and is grown throughout the tropics for human food, livestock forage, medicine, dye, and water purification. Moringa is grown traditionally as backyard trees or hedges for its leaves which are used domestically as culinary. The increased awareness of the multiple uses of Moringa leaves and seeds for both domestic and industrial purposes is leading to an increased demand for it, hence a view to evaluate farmers' response to cultivate *Moringa oleifera* as intercrop, determine the cost and returns of intercropping *Moringa oleifera* and cowpea and identify the problems facing cultivation and processing of Moringa- Cowpea intercropping in the area.

OBJECTIVES OF THE STUDY

- to evaluate farmers' response to cultivate *Moringa oleifera* as intercrop
- determine the cost and returns of intercropping *Moringa oleifera* and cowpea
- identify the problems facing cultivation and processing of Moringa- Cowpea intercropping in the area.

MATERIALS AND METHODS

This study was conducted in Sabon-Gari local Government area of Kaduna State, Nigeria. It is estimated to cover an area of about 600sqkm and has an estimated population of about 1.2 million people according to 1991 census. The population is projected to be about 1.8 million people in 2011. It is located on latitude $11^0 12^0$ north of the equator and longitude $07^0 37^0$ east of the prime meridian. It has average annual rainfall of 1500mm. Humidity is low in January between 15-35% and high in July between 65-85%. Annual temperature is between 24-28oC. The soil is generally described as sandy loam. Major occupation of the people is farming, trading, fishing and civil servants. A random sampling procedure was used in the study and questionnaires were administered to all the respondent at the study areas

Descriptive statistics and Gross Margin Analysis were used to achieve the objectives of this study. Descriptive statistics involved the use of frequency distributions, percentages and ranking using pie chart. The gross margin analysis was employed to determine the difference between the farmers' gross income and total variable cost. The selected farmer's costs and returns per hectare of land cultivated and average cost and average revenue per hectare of land cultivated was obtained from the gross margin analysis.

The mode for gross margin is expressed as: GM = GI – TVC

Where: GM = Gross Margin (N)

GI = Gross Income

TVC = Total Variable Cost

Gross Margin is a good approximation of Net Farm Income since small scale farmers usually have negligible fixed costs (Olukosi and Erhabor, 1988).

RESULTS AND DISCUSSION

The result of farmers' response to intercropping of Moringa with Cowpea is presented in Table 1. About 42% of the farmers responded positively and are ready to go into Moringa-cowpea intercropping, 40% said no while 18% were undecided. This explains reservation people have to new innovation.

Table 1: Farmers' response to intercrop Moringa with cowpea

Responses	Frequency	Percentage (%)
Yes	21	42
No	20	40
Undecided	9	18
Total	**50**	**100**

Sabon gari local government area 2014

The results in Table 2 present the Costs, Returns and Profitability of Moringa/Cowpea Production.

The result showed that 1ha plantation of Moringa oleifera gave a return of thirty seven thousand five hundred naira (₦37, 500) whereas cowpea on the same land gave returns of eighty two thousand, four hundred naira (₦82, 000). The gross margin of ₦65, 180 was realized from Moringa/cowpea intercrop. Sole cropping of cowpea generated gross margin of ₦27, 680 representing 45.5% of the profit. It is also noteworthy that Moringa and Cowpea cost of production is complemented and not distinctive thus saving cost of planting them separately. The naira spent value of ₦2.20 implies on every naira invested, the sum of ₦1.20k gain is made thus Moringa/Cowpea intercrop is a veritable business and profit oriented.

Table 2: The Result of Gross Margin Analysis

Items of Costs and Returns (₦)	Total	% contribution
Income:		
Moringa seed Revenue	37,500	31.4
Cowpea Revenue	82,000	68.6
Gross Income	119,500	
Variable Costs:		
Land preparation	8,000	14.7

Moringa seeds	5,100	9.4
Cowpea seeds	6,720	12.4
Pesticides	4,000	7.4
Planting	2,800	5.1
weeding	13,200	24.3
harvesting	4,000	7.4
Transport	4,000	7.4
Logistics	6,500	11.9
Total Variable Costs	54,320	
Gross Margin (intercrop)	65,180	57.5
Gross Margin (cowpea)	27,680	42.5
Return per N spent	440,500	**120**

Sabon gari local government area 2014

In Figure 1, 60% of the population agreed that Moringa products are accessible, 36% did not agree and 4% undecided. This is implicative that there is future for Moringa marketing.

Figure 2 revealed that 72% of the population agreed that Moringa has market acceptability if processed while the remaining 28% did not agree. This result however strengthens the conviction that marketability of Moringa products is on the positive side.

Figure 3 revealed Farmers' response to reality of problems in Moringa intercrops. It was observed that 64% of the population agreed that there are challenges facing Moringa intercropping while remaining 36% do not see any challenge. This majority subscription is a factor negating farmers' readiness to involve in mass production. Figure 4 showed the ratio of farmers attempt to manage challenges facing Moringa intercropping. 32 farmers that agreed there are challenges facing Moringa cultivation, 75% had made attempt to resolve the challenges while remaining 25% did nothing. Figure 5 showed Farmers' success in resolving the challenges that only 29% were successful, 23% partially successful and majority represented by 48% were not successful.

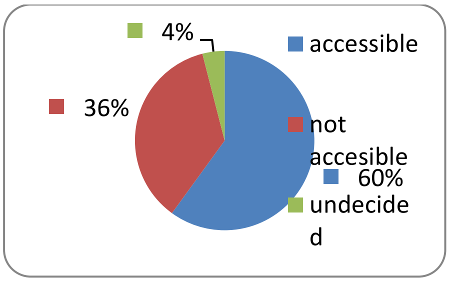

Fig 1: Farmers' response to moringa marketability

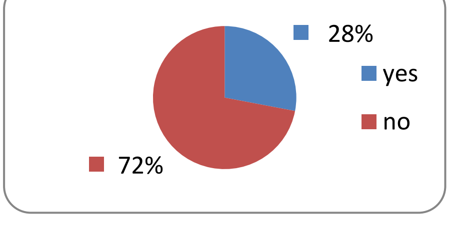

Fig 2: Farmers' response to market acceptability

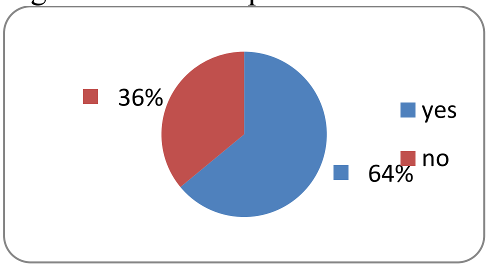

Fig 3: Farmers percentage facing challenges in Moringa management

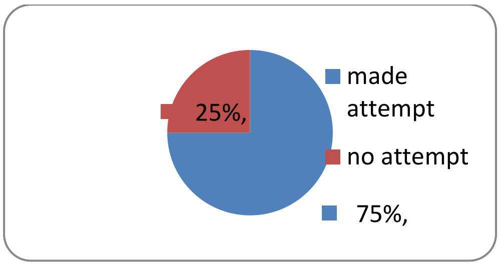

Fig 4: Farmers' percentage attempted to solve the challenges

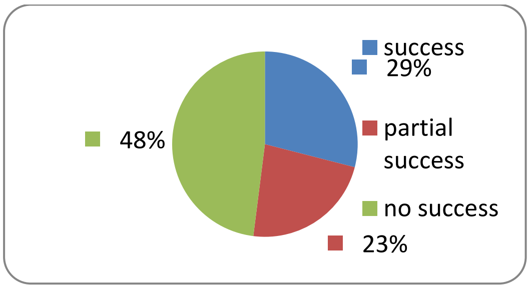

Fig 5: Farmers percentage of success in solving the challenges

CONCLUSION AND RECOMMENDATIONS

It is evident from this study that Moringa oleifera cultivation either as sole or intercrop is still a novel idea among Nigerian farmers despite its acclaimed economic values and importance. Many farmers are not aware of the multi various uses of the plant but a lot of them are willing to plant it if introduced to them. The need to place action on popularizing the plant among the Nigerian farmers is becoming evident. The result of this study has demonstrated beyond doubt that many farmers are aware of the existence of *Moringa oleifera* and are quite familiar with its traditional usage. Their understanding of its modern use is still at the mediocre level and thus the need to expose them further to its various processing becomes more relevant. Their readiness to adopt and utilize various technique learnt during the study is real and commendable but such enabling atmosphere of available land, storage facilities, equipment for processing, accessibility to all marketing chains are very evident. This study therefore recommends that there is a need for more training and awareness campaign for both farmers and extension agent in harnessing all the potentials of Moringa.

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Profitability of Cocoyam Production in South East, Nigeria.

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ABSTRACT

Profitability of cocoyam production in South East, Nigeria was studied using 400 sampled farmers. Structured questionnaire was used to collect primary data. Percentage responses and Net farm income were used to address the objectives of the study. The result of data showed that cocoyam production was profitable in the study area with Net Farm Income of 660,800 and Benefit cost ratio of 0.33. Also, the major constraints to cocoyam farming were; poor access to credit and high cost of labour. The need to enhance farmers' access to credit and labour saving devices were recommended.

Keyword Profitability, Cocoyam, Production, South East, Nigeria**.**

INTRODUCTION

The importance of cocoyam in enhancing economic growth is well acknowledged. Its prominence lies on ensuring food security, income generation and nutritional enhancement (FAO, 2020). Cocoyam compare to other roots and tubers have some intrinsic features that endeared it's production, included not having vines to stake as in yam (*discorea sp*), no strong obstructing stem as in cassava (*Manihot spp*) and no entangling vines like in sweet potato (*Ipomea batata*) which may obstruct its production (Okoye, *et al;* 2009),as yielding 30 – 60 metric tons/ha more than any root and corms, very low in starch gains, prone to mechanization using machinery, equipment and selection of clones, to reduce labour costs of production from 49% to 25% (NRCRI, 2021).

Nigeria is the largest producer of cocoyam in the world in terms of volume of production with the annual output of 5,068,000 metric tons/annum in 2019, (which represents 37% of the world output of cocoyam) as against the potential of 160 million metric tons/annum (FAO, 2020). The inability of the crop to meet its potentials could be correlated to storage problems, increasing input costs, labour scarcity, land scarcity, inadequate technical know-how among cocoyam growing farmers, lack of extension services, poor road network, perishability of planting material, unavailability and ignorance in the use of agrochemicals (fertilizer, pesticides etc) (NRCRI, 2021). The effect of the aforesaid problems is low productivity, leading to low yield. Therefore, there is need to assess the farmers' socioeconomic characteristics as it affects their performances in farming and their productivity in terms of profit accruing from their cocoyam production in the study area. This could aid in formulation and implementation of policies that will propel the farmers to improve on their productivity and among others. The main objective of the study is to determine the profitability and constraints to cocoyam production in the study area.

MATERIALS AND METHODS

The study was conducted in South east of Nigeria. The zone lies between 5 9'and 7 75'N of equator and longitude 6 85' and 8 46' East of Greenwich meridian time. .It has a total land area of 10952400 hectare. It comprises of five states; Imo, Anambra, Ebonyi, Abia and Enugu. Four states (Enugu, Ebonyi, Imo and Anambra) were purposively chosen because of intensity of cocoyam in these areas. Multi stage sampling technique was employed in selecting 100 cocoyam farmers from each state. A total of 400 respondents were interviewed with questionnaire and oral interview schedule for the study. Percentage responses and net farm income were used to capture the farmers' socio-economic characteristics, cocoyam profitability and constraints to the crop production in the study area.

Model Specification

Gross margin analysis. Gross margin = G.M. = TR – TVC ....(1)

i.e. G.m = $\sum_{1-1}^{n} P_1 Q_1 - \sum_{j-1}^{m} r_1\, x_i$ ....(2)

...The Net farm income can be calculated by gross margin less fixed input. The net farm income can be expressed as thus:

NFI = $\sum_{1-1}^{n} P_1 Q_1 - \left[\left(\sum_{j-i}^{m} r_i x_i\right) + k\right]$
....(3)

Where:
Gm =gross margin (₦), NFI = net farm income (₦), p1 = market (unit) price of output (₦), q = quantity of output (kg). Ri = unit price of the variable input (kg), xi = quantity of the variable input (kg), k = annual fixed cost (depreciation) (₦)

RESULTS AND DISCUSSION

Results and Discussion

Table 1 showed that 78% of cocoyam farmers were females, while 22%, males. Cocoyam cultivation according literatures is stereotyped female crop in many cocoyam producing areas (Ezedinma, 2006). As well, 64% of the respondents (17-41) were youths who can withstand strains and rigors associated with farming (Ume, *et al;* 2013). On farmers' farming experience, 40% of the farmers had farming experience of 10-14 years, while the least (10%), 1-4 years. Years of farming experience helps farmers to set realistic targets (FAO, 2020). Furthermore, the level of farming experience one acquired in a particular occupation, as reported by Eze and Okorji, (2004) could contribute significantly to his/her level of managerial ability and decisions in farm operations. These consequently results in high level of competence in utilization of resources for optimal productivity. Most (70%) of the respondents operated between farm size of 0.1-2.0 ha, which implies that the farmers are small scaled farmers. This is in line with apriori knowledge that farmers in most developing countries are small scaled in their operations and with their farms scattered (Okoye, *et al;*2009). Furthermore, 80% of the farmers had formal education, while 20% did not. The high educational attainment is a desirable condition for agricultural development, since it augured well for extension services in transferring research result for sustainable food production (NRCRI, 2020). In related study in cocoyam production across gender in Enugu North agricultural zone of Enugu State of Nigeria. Okoye *et al;*(2009) reported that educational accomplishment enhances managerial skills, resource management, decision making and adaptability of an individual. for higher productivity to be attained.

Among the variable costs used in cocoyam production as in Table 2, the cost of labour, 50.815 was the highest, while cost of the physical input (cocoyam sett, fertilizer, and miscellaneous), 39.41%. The cost of labour as reported in farming among peasant farmers could be related to near zero of farming crops like roots, tubers and corms. As well, the urban drift of able-bodied youths for white "collar job", hence leaving those labourers (youths) to charge higher to keep afloat with those in urban area(Ume, *et al;*2016). Also, the Table 2 revealed that the total revenue was ₦940,000, gross margin of ₦688800; Net farm income; ₦660, 800 with Benefit cost ratio of 0.33. Table 3 shows the constraints to cocoyam production of which 91 % of the total respondents complained of poor access to credit and ranked first. Credit facilitates adoption of innovations in farming, encourage capital formulation and marketing efficiency (Ume, *et al;* 2013). The poor access to credit could because of delay in loan approval and late release of fund to farmers during planting season and short repayment period (Okoye, *et al;*2009). Addition, 87.5% of the sampled farmers encountered the problem of high labour cost and ranked second. Urban drift of youths and feminization of agriculture may have contributed in labour being inelastic and expensive, consequently low returns results (Ume, *et al;*2016). As well, the least, (36%) was Fulani herders problem. The recent ban of herders in the region could be attested for the low percentage contribution to the constraints.

Table 1: Distribution of Respondents According to Socioeconomic Characteristics

Factors	Frequency (n=120)	Percentage
Gender (dummy)		
Male	312	78
Female	88	22
Age in Years		
1-20	16	4
21-41	240	60
42-62	80	20
63 and above	64	16
Household Size (No)		
1-5	176	44
6-11	200	50
12-17	16	4
18 and above	8	2
Farm Size (ha)		
0.01-1.00	200	50
1.01 – 2.00	80	20
2.01 – 3.00	20	5
3.01 – 4.00	28	7
4.01 – 5.00	8	2
> 5.00	24	6

Years of Farming Exper. (yrs)		
1 – 4	40	10
5 – 9	80	20
10 – 14	160	40
15 and above	120	30
Cooperative membership	260	65
Level of Education(yrs)		
No formal education	40	10
Primary Education	180	45
Secondary Education	100	25
Tertiary Education	80	20

Source: Field Survey, 2015.

Table 2 Profitability of Cocoyam Production

Variable	Amount(N)	% of TC
Total revenue	980,000	
Variable Cost		
Cocoyam sett	54,000	16.91
Fertilizer	60000	18.80
Miscellaneous	15,000	4.70
Total physical input	129, 000	3 9.4 1
Labour		
Land preparation	80,000	25.06
Planting	7200	2.26
Fertilizer	15000	4.70
Weeding	35,000	11
Harvesting	25,000	7.82
Total labour cost	162,200	50.81
Total Variable cost	291,200	
Gross margin(TR-TVC)	688,800	
Depreciation	28,000	
Total cost	319,200	
Net farm income(TR-TC)	660800	
Benefit cost RatioTC/TC	0.33	

Source, Field Survey, 2021

Table 3 Constraints to Cocoyam Production in the Study Area

Problems	Frequency	Pert.	Ranking
Poor access to credit	364	91	1st
High labour cost	350	87.5	2nd
High cost of fertilizer	340	85	3rd
High cost of planting material	317	80	4th
Inadequate extension contact	314	78.5	5th
Fulani herders	136	36	6th

Source: Field Survey, 2021

Source: Field Survey, 2021* Multiple responses

Conclusion and Recommendations

The constraints to cocoyam production in the study area were poor access to credit and high labour cost. There is need to increase farmers access to credit through microfinance bank and other financial institutions. As well, the need to develop labour saving devices such as hand driven ploughs through research and disseminate to the farmers.

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Livelihood Diversification among Sugarcane Farmers in Niger State, Nigeria: Patterns and Determinants

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ABSTRACT
Using data from 120 small-scale sugarcane farmers in Niger State of Nigeria, this study examined the farmers' livelihood diversification and its determinants using logit regression. The results show that a majority of the farmers were male (87.5 percent), married (75.8 percent), having family size of 6-10 persons (30.8 percent), above 40 years of age with farming experience of above 10 years. Majority (93.3%) of the farmers diversify to generate more income, while 57% diversify to disengage from farming, 14% do not diversify due to availability of government grant. Access to market and weather condition significantly affect the farmers 'choice of livelihood diversification. The study recommends the promotion of non-farm employment as a good strategy for supplementing the income of farmers, as well as sustaining equitable rural growth.

Keywords: determinants, diversification, livelihood, Logit regression, sugarcane

INTRODUCTION
For many years, agriculture has been the primary source of income for rural residents. However, in recent years, as a result of low agricultural productivity, rural livelihoods have expanded to include not only agriculture but also business, services, remittance, and non-farm work (Jayne et al., 2014). Over time, household land holdings have decreased, and the agricultural sector's breadth has likewise shrunk (Djurfeldt, 2015). Agriculture is a risky investment due to the volatility in price and vagaries of weather. The risk and seasonality in agriculture has triggered the diversification of rural farmers from farming activities to other less risky and non-farm activities (Adepoju & Obayelu, 2013).

Livelihood comprises the capabilities, assets and activities required for a means of living (Oyinbo & Olaleye, 2016). A livelihood is sustainable when it can cope with and recover from the stresses and shocks and maintain or enhance its capabilities and assets both now and in the future without undermining the natural resource base (Roscher et al., 2022). Livelihood diversification is a process whereby households add new activities, maintain existing ones or drop others, thereby maintaining diverse and changing livelihood portfolios in order to survive and to improve their standard of living (Babatunde, et al., 2015).
Diversification is not only considered a risk management strategy, but also a means to increase overall income.
In Nigeria, where farm size average is small, poverty and food insecurity remain high among small landholders, the concept of sustainable agriculture through livelihood diversification should be viewed in the context of the need to improve farmers' economic conditions. All of this necessitates a thorough examination. Nevertheless, studies that have addressed this are rare in Nigeria to the best of researchers' knowledge. Hence this study to examine the livelihood diversification strategies employed by the sugarcane farmers, identify factors that determines the status of livelihood diversification strategies. Knowledge of livelihood diversification strategies and their determinants could be of great value for policy makers in designing effective diversification activities to improve small-scale farmers' livelihood.

MATERIALS AND METHODS

Study Area

The study was conducted in Niger State of Nigeria. Niger State is situated in the north-central geopolitical zone of Nigeria. The state lies between latitude 3.20° East and longitude 11.30° North, with a land mass of 86,000km^2 the state shares a country border with the Republic of Benin (West) and state borders within Nigeria. These include the Federal Capital Territory (FCT) on the South-East, Zamfara (North), Kebbi (North-West), Kwara (South-West) and Kaduna (North-East). Due to soil fertility and ample supply of water, the major crops cultivated in the state include sugarcane, rice, maize, and wheat.

Data Sources

A two-stage sampling technique was used to select the sample for the study. The first stage involved the purposive selection of two Local Government Areas (LGAs) in the state: Mokwa and Paikoro, due to the high prevalence of sugarcane production in the area. The second stage involved the random selection of 120 small-scale sugarcane farmers from the list of Sugarcane Farmers Association in the selected LGAs. Data for the study were collected using interview guide with structured questionnaire and were analysed with descriptive statistics and logit regression. Descriptive statistics was used to analyse respondents' socio-economic characteristics, livelihood strategies employed and constraints. The determinants of diversification status of farmers were analysed with logit regression.

Model specification ***(****Logit Regression****)***

The dependent variable (Zi) is dichotomous and takes the value 1 for the diversified farmers and 0 for the non-diversified farmer (Awotide, 2011). The model is given as:

$$Z_i = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 \dots + b_8 X_8 + U$$

Where: Zi =Livelihood diversification status of the household (1=diversified, 0=otherwise)
X_1 = Access to Market (sold directly =1, through 3rd party, agents/others = 0)
X_2 = Level of Education

X_3 = Weather uncertainty (Dummy)
X_4 = Amount of Credit Accessed (Naira)
X_5 = Risk and Uncertainty (Dummy)
X_6 = Sugarcane Income (Naira)
X_7 = Farm location (Km)
X_8 = Subsistence Farming (Dummy)
U = Error term

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the farmers

The result of the socio economic characteristics of the farmers shows that most of the farmers (88%) are male, and has most of their ages above 40 years. The arduous tasks associate with sugarcane production may explain the limited female participation. Majority of the farmers been in their middle age could result in positive effect on the efficiency of their farming.

Majority of the respondents (76%) with a mean household size of 8. Most of the farmers, 27%, have no formal education. This can negatively affect their adoption of new technologies.

Table 3: Socio economic characteristics

Variables	Frequency	Percentage	Mean (include standard deviation)
Sex			
Male	105	87.5	
Female	15	12.5	
Age			**40**
18 – 25	20	16.7	
26 – 30	19	15.8	
31 – 40	28	23.3	
>40	53	44.2	
Marital status			
Single	23	19.2	
Married	91	75.8	
Divorced	1	0.8	
Widowed	5	4.2	
Household size			**8**
1 – 5	31	25.8	
6 – 10	37	30.8	
11 – 15	33	27.5	
>15	19	15.8	
Level of education			
No formal	33	27.4	
Primary	29	24.2	
Secondary	29	24.2	
Post-secondary	29	24.2	
Farming experience			**10**
<1	17	14.2	
1 – 5	22	18.3	
6 – 10	24	20.0	
>10	57	47.5	
Access to market			
Yes	107	89.2	
No	13	10.8	

Source: Field Survey, 2021

3.2: Sugarcane farmers Livelihood Diversification Patterns

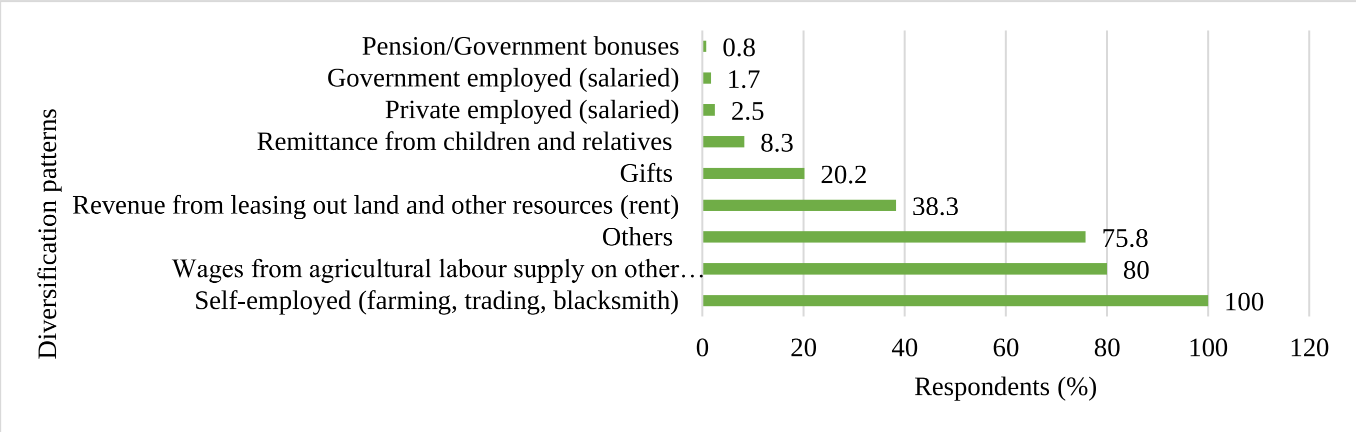

Figure 5: Diversification patterns
Source: Field survey, 2022

3.3. Sugarcane farmers Diversification Strategies

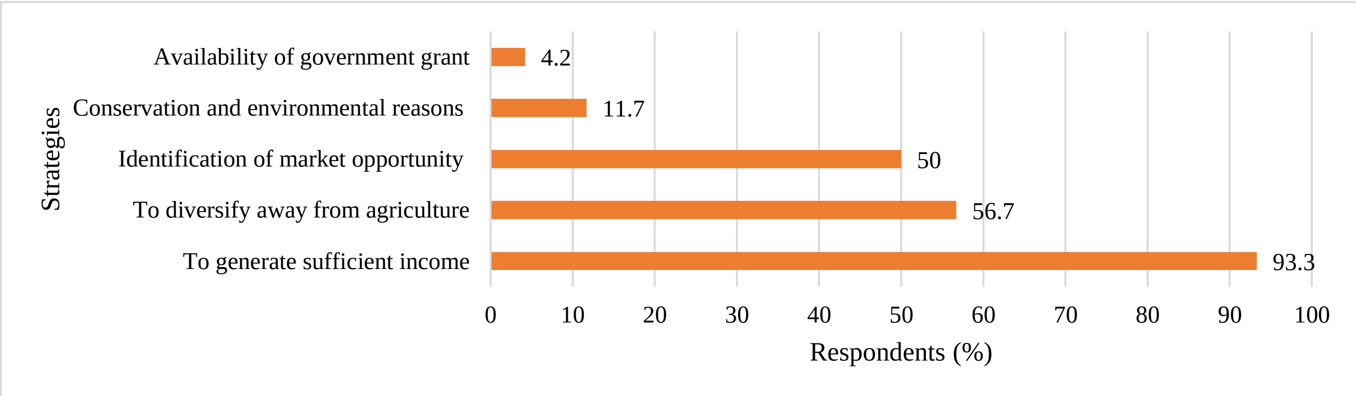

Figure 6: Reasons for diversification
Source: Field survey, 2022

Determinants of livelihood diversification among sugarcane farmers
Access to market and Weather (climate) has significant effect on the livelihood diversification of the farmers with a significance level at 0.1 and 0.05 respectively as shown in table 2.
Access to market significantly affect the farmers' choice of livelihood diversification, with a positive coefficient of 3.9. This implies that; increase in access to market will cause the farmers to diversify their source of livelihood from sugarcane farming into other line of production or agribusiness. This might be because of the several opportunities market brings and the likelihood of making profit from activities which require lesser labor in comparison to farming.
Also, weather is significant with a positive coefficient of 4.2. This implies that increase in the uncertainties of weather condition affects the farmer's choice of diversifying from sugarcane production into other line of agribusiness or completely leave production for marketing or distribution of agricultural product.

Table 4: Determinants of livelihood diversification among sugarcane farmers

Variables	Coefficient	Std. Err.	z	P>|z|
Access to market	3.909737	1.070081	3.65	0.000
Level of education	-.3168729	.4796984	-0.66	0.509

Weather	4.203093	1.73578	2.42	0.015
Access to credit	2.397278	1.612016	1.49	0.137
Risk and uncertainty	.662312	1.131123	0.59	0.558
Sugarcane income	1.318575	1.273256	1.04	0.300
Farm resident	-.7820552	1.261167	-0.62	0.535
Subsistence farming	1.445092	1.269591	1.14	0.255
constant	-5.946412	2.875114	-2.07	0.039
Number of observation	120			
LR chi^2	27			
Prob>chi	0.0007			
Log Likelihood	-18.389142			
Pseudo R^2	0.4233			

Source: Field survey, 2022

CONCLUSIONS

The study confirmed that sugarcane farmers in the study area are predominantly middle- aged male and they earn their income majorly through on-farm income and seldom through off-farm and non-farm income.

- The study recommends the promotion of non-farm employment as a good strategy for supplementing the income of farmers as well as sustaining equitable rural growth.
- Training on Climate Smart Agriculture for the farmers by the extension agents is also recommended.
- Also, Government should provide basic standard infrastructures such as good accessible roads that connects farm to market for easier transportation.
- Additionally, Government or Non-Governmental associations should make loans, grants and even skill acquisition experience available to farmers who are willing to diversify their livelihood.

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Opinionated effects of climate variability on socio-economic status of arable crop farmers in Ogun state, Nigeria.

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ABSTRACT

Agriculture is dependent on climate for optimum production. Climate variability alter the level of expected output because climate has shifted from its normal or usual course. It has been variously documented that climate variability had impacted crop production negatively through crop damage leading to persistent low yield and thereby affecting farmers' socio-economic status. The study assessed the opinionated effects of climate variability on socio-economic status of arable crop farmers in Ogun state, Nigeria. Multi-stage sampling procedure was used to select 230 respondents. Majority (68.8% and 59.4%) of the respondents claimed that radio and extension agents, respectively, were the major sources of information on climate variability in the study area. Farmers who felt in their opinion that they eat what is available due to the effect of climate variability on their socio-economic status were ranked 1st. The result of Spearman Rho at p=0.01 revealed that there was a strong positive relationship between opinionated effects of climate variability and socio-economic status. It was therefore recommended from the findings that farmers must be proactive in taking actions on farming activities to mitigate the effects of climate variability.

INTRODUCTION

Arable crop and its production had gained prominence in ameliorating the challenges against food availability and food security especially in developing and underdeveloped countries of the world (Osabohien, Osabuohien and Urhie, 2018). Arable crops remain staple food in Nigeria as there is evidence that every household consume arable crops in different forms on daily basis (Sadiq, Oyelere and Olagoke, 2014). In the current food production and commerce scenarios, arable crops are playing roles of meeting food consumption and revenue generation, and consequently improvement in the socio-economic status of the farmers. Socio-economic status is used in determining the social ranking of an individual in relation to wealth, education, income, power as well as work status in the society. Therefore, the socio-economic status of the farmers will always be affected by the level of their farming productivity or output. Arable farmers' output is determined by total yields of the entire crop planted. In this situation, it is worth mentioning that what affects crop yields will affect farmers' socio-economic status. Climate variability will alter the level of expected output because climate has shifted from its normal or usual course. It has been variously documented that climate variability had impacted crops and that crop production was negatively badly affected through crop damage leading to persistent low yields thereby affecting farmers' socio-economic status (Sawe, *et. al.,* 2018; Islam, *et. al.,* 20016). A priori expectation is that when there is climate variability (a shift from normal climate situation) may not be so favourable to crop production (Oyelere, *et. al.,* 2019) which affect yields hence, socio-economic status.

To know what farmers think about the effects of climate variability on their crops is very germane to the determination of their crop yields. However, crop yield is a relevant indicator of knowing the level of farmers' wellbeing in the continuum of social ranking or socio-economic status. In order to know farmers' stance about the effects of climate variability on their socio-economic status, it is necessary to gather relevant information about their opinions. According to Kramer and Wadud (undated) gathering information on opinions is the process of finding out where people (in this case, arable crop farmers) stand on a particular subject matter in this situation which is the opinions about the effects of climate variability on socio-economic status of arable crop farmers. Hence, the study assessed the opinionated effects of climate variability on socio-economic status of arable crop farmers in Ogun State, Nigeria. The specific objectives were to identify the various sources of information on climate variability available to the respondents, determine yields and revenues of the respondents and determine the opinionated effects of climate variability on socio-economic status of the respondents in the study area. The only hypothesis was stated in null form that there is no significant relationship between opinionated effects of climate variability and socio-economic status of arable crop farmers in the study area.

METHODOLOGY

Structured interview schedule was employed to elicit the needed information from the respondents. Multi-stage sampling procedure was used to select 230 respondents for the study. Abeokuta and Ilaro zones of Ogun State Agricultural Development Programme (OGADEP), were purposely chosen to avoid sampling the same vegetation zone. Twenty percent (20%) of the blocks in each zone were randomly selected for the study; making 7 blocks in Abeokuta zone and 5 blocks in Ilaro zone. Ten percent (10%) of the registered arable crops farmers from the selected blocks were randomly chosen to give one hundred and twenty (120) and one hundred and ten (110) arable crop farmers from Abeokuta zone and Ilaro zone, respectively to give two hundred and thirty respondents (230) for the study during 2017-2019 cropping seasons.

RESULTS AND DISCUSSION

Mean yields and revenues of selected arable crops in three planting seasons

Table 1 shows the trend of yields and revenues of selected arable crops in three consecutive planting seasons in the study area. The apparent trend of maize yields and revenues between 2017-2019 cropping seasons revealed a downward trend. Also, when compared farmers' yields with expected yields, it resulted in reduced yields and this translated into sustained colossal losses. Data in the Table further revealed that in year 2017, percentage revenue loss for maize was 77.1%, in the year 2018, it was 78.1% while in the year 2019, the percentage loss was 80.3%. This huge loss, all things being equal, could be traced largely to climate variability. Yield trends of ysam production during 2017-2019 cropping seasons showed a sustained yield loss and supposedly, reduced revenue leading to high percentage loss in expected revenue. The trend of percentage revenue loss for yam in 2017, 2018 and 2019 were 76.1% 76.8% and 79.7%, respectively. Equally, trends of cassava yields in 2017-2019 showed a reduced trend. By extrapolation, the percentage of expected revenue loss kept increasing; such as 40.47%, 49.25% and 89.5%, respectively. A cursory look at the data suggested that the trends of yields and expected revenues of the three crops under review had been reducing. Maize was the most hit by the effect of climate variability when juxtaposing the data of the three crops. This indicated that maize was easily vulnerable to the shocks arising from vagaries of weather. Although maize has high production potentials, Olaniyan (2015) asserted that repeated drought, erratic rainfall, and stoppage of rainfall during cultivation period hinder optimum production of maize. However, yam and cassava were not so much affected or devastated like maize. Probably, this was due to fibrous root of maize that could not hold water while yam and cassava are tuberous crops whose tubers are prone to holding water. Data further revealed that cassava was least affected by vagaries of weather as it was not phenomenally affected. This was an indication that cassava was a tough crop that has the capacity to withstand the effect of climate variability than maize and yam.

Table 1: Average yields and revenues of selected arable crops in three planting seasons

Planting seasons	Farmers' mean yields(ton)	Average price per ton (N)	Average revenue(N)	Expected yield / ha	Recommended expected revenue(N)	% Loss
Maize						
2017	2.38	44,500	105,910	10.4	462,800	77.1
2018	2.28	52,000	118,560	10.4	540,800	78.1
2019	2.05	68,000	139,400	10.4	707,200	80.3
Yam						
2017	2.39	28,000	66,920	10.00	280,000	76.1
2018	2.32	35,000	81,200	10.00	350,000	76.8
2019	2.03	42,000	85,260	10.00	420,000	79.7
Cassava						
2017	6.31	10,000	63,100	10.6	106,000	40.47
2018	5.38	16,000	86,080	10.6	169,600	49.25
2019	3.39	22,000	24.580	10.6	233,200	89.5

Source: Feld survey, 2020

Opinionated effects of climate variability on socio-economic status of respondents

Results from Table 2 have shown the opinionated effects of climate variability on socio-economic status of arable crop farmers in Ogun State, Nigeria. Results from Table 3 reveal that farmers, who felt in their own opinion that they eat whatever is available ranked 1st while those who opined that they cannot feed their children as a result of the effects of climate variability ranked 2nd. Table 3, also reveals that all the parameters investigated were crucial to the standard of living of the respondents, and in the opinions of the respondents had negatively impacted as a reason of climate variability. Hence, their socio-economic status was badly affected because Akinbile (2007) had described socio-economic status as the relative position which an individual occupies in a society concerning the amount of cultural possession, effective income, material possession, prestige and social participation. This then implies that the respondents' socio-economic status had been negatively affected by the effects of climate variability because education, income and health which are socio-economic status indicators had been badly affected as revealed in the table.

Table 2: Opinionated effects of climate variability on socioeconomic status

Opinionated effects of climate variability	WMS	RANK
We eat what is available	3.00	1st
I cannot feed my children	2.98	2nd
My children go to school in turns	2.91	3rd
Borrowing money from people	2.91	3rd
Cannot service membership in social organisations	2.91	3rd
Annual income has reduced	2.89	6th
Enterprise reduce to subsistence level	2.89	6th
Evasion of commodity tax	2.88	8th
Cannot build house	2.78	9th
Health deteriorating daily	2.78	9th
Many children cannot go beyond primary education	2.77	11th
I have withdrawn many children from school	2.72	13th
No possession of additional valuable materials	2.77	11th
Support towards community declined	2.70	14th
Swapping property for money	2.66	15th
I buy fairly used clothes	2.66	15th

WMS= Weighted Mean Score
Source: Field survey, 2020

Test of hypothesis

There is no significant relationship between opinionated effects of Climate variability and socio-economic status of arable crop farmers. Spearman Rho revealed the relationship between the opinionated effects of climate change and level of socio-economic status and was presented in Table 4. The r_s value of 0.985 and p value of 0.000 showed that there was a strong positive significant relationship at 0.01 level. It implies that the variability in climate has really affected the yields of arable crops; which translated into reduced income and socio-economic status that depends on farmers' income. Therefore, the biting/harsh effect of climate variability could have been the cause of low Socio-economic status of the arable crop farmers in the study area.

Table 3: Summary of Spearman's rho analysis showing relationship between opinionated effects of climate variability and socio-economic status

			Index SES	Index climate variability
Spearman's rho	Index SES	Correlation Coefficient	1.000	.985**
		Sig. (2-tailed)	.	.000
		N	320	320
	Index climate change	Correlation Coefficient	.985**	1.000
		Sig. (2-tailed)	.000	.
		N	320	320
**. Correlation is significant at the 0.01 level (2-tailed).				

Source: Field Survey, 2020

CONCLUSION AND RECOMMENDATIONS

The rurality of the respondents made them utilize the cheapest means of communication for getting information on climate variability. The yields and revenues accrued to the farmers in the study area had followed a reducing trend. Reduction in yields led to reduction in revenues to the farmers. In the opinions of the arable crop farmers in the study area, their socio-economic status was negatively affected. It was hereby recommended that farmers must be proactive in taking actions on farming activities to mitigate the effects of climate variability.

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Analysis of Cassava Based Farm Households' Total Incomes from different Sources in Umuahia Agricultural Zone of Abia State.

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ABSTRACT

The study analyzed the composition of male and female headed cassava farm households. Total incomes from different sources in Umuahia Agricultural Zone Abia State and was guided by the following specific objectives; describe the socio-economic characteristics of male and female headed cassava based farm household in the study area; analysed composition of households was used in selecting 144 cassava-based farm households (consisting of 72 male-headed and 72 female-headed cassava-based farm households). The socio-economic profiles of male and female-headed cassava based farm households showed that the mean ages of male and female heads of cassava-based farm household's were54.09 and 46.42 years with mean 5.00 and 4.00 persons respectively and mean years of cassava farming experience 19.35 and 12.56 years respectively. The result on composition of annual total incomes indicated that all males and females-headed cassava farm households derive income from farming (48.07% and 56.69%) of annual total income in male and female-headed cassava farm households respectively. The study recommended that improved cassava varieties with short gestation periods should be extended to the farmers in the rural areas.

INTRODUCTION

Cassava makes a significant contribution to the rural economy's revenue and food security because of its ability to generate a respectable yield in a variety of soil types and its tolerance of drought (Osondu *et al*., 2014). Cassava production alone cannot provide sufficient livelihood opportunities for farmers hence there is a need for male and female headed households to embark in multiple income generating activities as a coping strategy to improve household livelihood and reduce poverty (Onwusiribe 2018). Both male- and female-headed agricultural families in Nigeria cultivate cassava more frequently than other crops.

Poor subsistence farmers are the principal growers of this crop, and women are mostly in charge of its processing into various products. The majority of Nigerian households who grow cassava rely on farming for the most of their revenue and survival, but occasionally they also participate in non-farming activities to augue their agricultural income (Odoemenem, 2013).

The headship of a household is usually identified with the person who has a greater authority in the household. Power and authority may be vested in the member who has control over the general affairs of the family unit, including decision making concerning economic, social and political interactions. Vander Toom (2015) asserts that while females are recognized potential household heads, in reality men are most often ascribed the headship position, a practice that still subscribes to the patriarchal view that men provide for the family while females nurture it. Thus, headship may be assigned without due regard to the actual economic contributions of the female members.

Multiple income generating activities refer to those incomes earned by the farmer from nonfarm income generating activities at different times of the year (Barrett *et al.*, 2001 and Carletto *et al*., 2007). Multiple motives prompt male and female headed cassava based households to diversify assets, incomes, and activities. According to the World Bank (2003), Lanjouw and Lanjouw (2001) male and female headed cassava based households world-wide embark in a variety of multiple activities to generate income. The engagement in multiple income generating activities is peculiar to rural farming communities in Africa. The major multiple income generating activities which the female headed cassava based households engaged in included food processing, trading, mat weaving and pottery, basket weaving, food vendoring, hair plaiting, petty trading, tailoring and collection of forest products (Oladeji, 2007). Also, male headed cassava based households embarked on multiple income generating activities such as black smiting, clothes weaving, carpentry, palm-tapping, welding, barbing, teaching, motorcycle (Okada) riding, brick layering, traditional medicine and transportation(Oladeji, 2007).

This research was guided by the following specific objectives to:

i. describe the socio-economic characteristics of male and female headed cassava based farm households in the study area;
ii. analyze composition of household's incomes from different sources in the study area;

RESEARCH METHODOLOGY

The study was conducted in Umuahia Agricultural Zone of Abia State, Nigeria. The sampling technique involved the use of multistage random sampling technique. In the first stage, three (3) Local Government Areas LGAs were randomly selected from the five LGAs that make up the agricultural zone. The selected LGAs were Ikwuano, Isiala Ngwa South and Umuahia North. In the second stage, two autonomous communities were selected randomly from each of the three selected LGAs, making a total of six (6) autonomous communities. The selected communities were Ibere, Ariam, Ama-AsaaNsulu, Ovungwu, Ibeku and Afaraukwu. This was followed by a random selection of two villages from each of the selected communities, making a total of 12 villages. From each of the chosen villages, a random selection of six (6) male-headed cassava-based farm households and six (6) female-headed cassava-based farm households was done using a list formulated with the help of natives. This gave a total of 144 cassava- based farm households (consisting of 72 male-headed and 72 female-headed cassava-based farm households). Primary data were elicited by use of a pre-tested and structured questionnaire for the study. However, 140 respondents' questionnaire were found usable for analysis.

Descriptive statistics such as frequencies, tables, means and percentages were used to analyze objectives (i) and (ii)

RESULTS AND DISCUSSION

Socio Economic Characteristics of Respondents

The Socio-economic profiles of male and female-headed cassava-based farm households in Umuahia Agriculture Zone is presented in Table 1. The Table shows that the mean ages of male and female heads of cassava-based farm households were 54.09 and 46.42 years. This implied that both male and female heads of cassava-based farm households were within the national active productive workforce age of 18 to 65 years and have the ability to withstand the rigours, strain and stress involved in cassava production (Onyenucheya and Ukoha, 2007).

Also, table 1 shows that the mean household sizes of male and female heads of cassava-based farm households were 5 and 4 persons respectively. This is a manageable household size. Higher household size can lead to high level of malnutrition, mortality, illiteracy, unemployment especially in the rural economy because income generated from different sources by the household may not be enough to take care of the needs of the family members which led to a change in family emphasis as reported (Ezeh, 2007).

Table 1 further shows that the mean years of cassava farming experience of male and female-heads of cassava households were 19.35 and 12.56 years respectively. This implies that headship of both groups of respondents were established and knowledgeable in cassava production. The number of years spent in farming give an indication of the practical knowledge acquired on how to overcome certain inherent problems in such a farm enterprise (Okolo, 2007).

Table 1: Distribution of Male-heads and Female-heads of Cassava-based Farm households by Socio-economic characteristics in Umuahia Agricultural Zone of Abia State, Nigeria

Variables	Male-Headed		Female-headed	
	Frequency (N=70)	Percentage	Frequency (N=70)	Percent age
Age (years)				
30-40	16	22.86	29	41.43
41-50	19	27.14	23	32.86
51-60	24	34.29	12	17.14
Above 60	11	15.71	6	8.57
Mean (years)	54.09		46.42	
Household size				
1-4	17	24.29	52	74.26
5-9	31	44.29	15	21.43
Above 9	22	31.42	3	4.29
Mean (5male Headed) (4 female headed)				
Farming experience(years)				

1-5	14	20.00	26	37.14
6-10	15	21.43	15	21.43
11-15	8	11.43	12	17.14
16-20	19	27.14	6	8.57
Above 20	14	20.00	11	15.71
Mean (years)	19.35		12.56	

Source: *Field survey 2018*

Composition of Annual Income Generation Sources in Male-Headed and Female- Headed Cassava Farm Households

Table 2 shows the composition of annual total income and contributions of different income sources to total income of male and female- headed cassava farm households in the study area. The table shows that all male and female- headed cassava farm households derive income from farming, which however, accounted for 48.07% and 56.69% of annual total income in male and female- headed cassava farm households respectively. Crop farming (primarily cassava), which mainly was subsistence in nature, was the most important single source of income for the respondents, providing about 26.36% and 32.70 % of total income in male and female-headed cassava farm households respectively. Despite the growing skepticism on the role of agriculture (cassava production) in reducing poverty among rural households, this result shows that, it remains the major source of income for rural households (Van den Berg and Kumbi, 2001; Karugia *et al*., 2006).

A good proportion of the male and female- headed cassava farm households derive income from livestock enterprises, but income from this source was only 8.9% and 13.35% of total incomes of male and female- headed cassava farm households respectively. This suggests that they keep small scale livestock extensively on free range. The other income (51.93% and 43.31% proportions for male-headed and female- headed cassava farm households respectively) were derived from different off-farm sources. Self-employed income was important in female-headed households as it accounted for 15.69% of total income. Self-employed income came mainly from handicrafts, food processing, shop-keeping and other local services, as well as trade in agricultural and non-agricultural goods. Similarly, a good number of male-headed farm households in the study area received income from off-farm sources with remittances being the most important. A good proportion of the income of male headed farm households is made up of remittances from local and international sources which contributed 19.07% of their total annual income. This was expected since many of the farmers are truly poor and could not have any of their household members residing far from home to remit money. This is a reflection of the vicious cycle of poverty. It would be risky for poor farmers to rely on this income source (Babatunde, 2008).

Table 2: Annual income from different sources in Male-headed and Female- headed farm households in Umuahia Agricultural Zone of Abia State, Nigeria

	Male Headed		**Female Headed**	
Income pattern	income per capita (₦)	Share of total income (%)	income per capita (₦)	Share of total income (%)
Total farm income	118,328.57	48.07	101,156.81	56.69
Crop income	64,888.57	26.36	58,341.43	32.70

Livestock income	22,011.43	8.94	23,815.38	13.35
Agric wage income	31,428.57	12.77	19,000.00	10.65
Total off farm income	127,807.14	51.93	77,269.9	43.31
Non-Agric wage income	13,671.43	5.55	12,244.9	6.86
Remittance	46,928.57	19.07	18,482.14	10.36
Self employed	29,285.71	11.90	28,000.00	15.69
Other incomes	37,921.43	15.41	18,542.86	10.39
Total household incomes	246,135.71	100.00	178,426.71	100.00

Source: Field survey, 2018

CONCLUSION AND RECOMMENDATION

The study established income diversification measures among the male and female headed cassava based households in the study area with income from crop being the dominant. It is recommended that improved cassava varieties with short gestation periods should as a matter of emphasis be extended to the farmers in the rural areas.

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Assessment of Nigeria's cashew industry: panacea for food security

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ABSTRACT

This study was carried out to assess cashew industry in Nigeria. Trend analysis was carried out to observe cashew yield, quantity produced and area(s) where it is harvested in Nigeria from 1990 to 2020. The study observed a sharp decline in cashew production around 2011 and 2012. Although there had been improvement in the on-farm production of cashew in Nigeria in recent years, the fact remains that the country has not been able to match its production levels of the early 2000s. It is also recommended that government invest massively in cashew research as this will encourage collaboration among stakeholders and scientists to come up with ideas on how to tackle the challenges besetting the cashew sector both locally and globally. Cashew is not just a cash crop; it also serves as a source of food material for households. Hence, the role of cashew in food security in Nigeria could become very vital if production levels are improved. This will increase farmers' income thereby improving their ability to afford other food products and also increase the local consumption of cashew. Therefore, efforts geared towards improving cashew production could improve food security in Nigeria.
Keywords: Nigerian, Cashew, Production, Trend, Food Security.

INTRODUCTION

Cashew (*Anacardium Occidentale L.*) is a multipurpose tropical tree crop whose origin is usually traced to the amazon basin in Brazil (Salau *et al*., 2017). The crop was introduced to Africa and Nigeria by the Portuguese explorers who visited the continent around the 15th and 16th century (Asogwa *et al*., 2008). The value attached to the crop was initially based on its ability to help against erosion and farm flooding; however, the edible apple was later recognised for its benefits. The most economic part of the fruit which is the nut was only recognised much later for its superior economic value and usefulness (Tola and Mazengia, 2019).

According to Adeigbe *et al.*, (2015), cashew was first planted in Nigeria at Agege in Lagos State; thereafter, the crop spread to other parts of the country. The crop was first planted for commercial gains in Nigeria in the mid 1950's at Ogbe, Oji, Mbala and Uji in the Eastern region and at Iwo, Eruwa and Oke-Ogun in the old Western Region (Asogwa *et al*., 2009). There were initial challenges in the cultivation of cashew in the country, which is as expected, was due to the novel nature of the crop when it was first introduced into the country. Another problem that arose was the poor state and neglect of cashew plantations around the country. However, by the mid-1980s the fortune of the crop changed as a result of the activities of private entrepreneurs, affluent farmers, and government agencies which ensured that more nuts were brought into the country from other climes and this improved the genetic base of Nigerian cashew (Adeigbe *et al*., 2015).

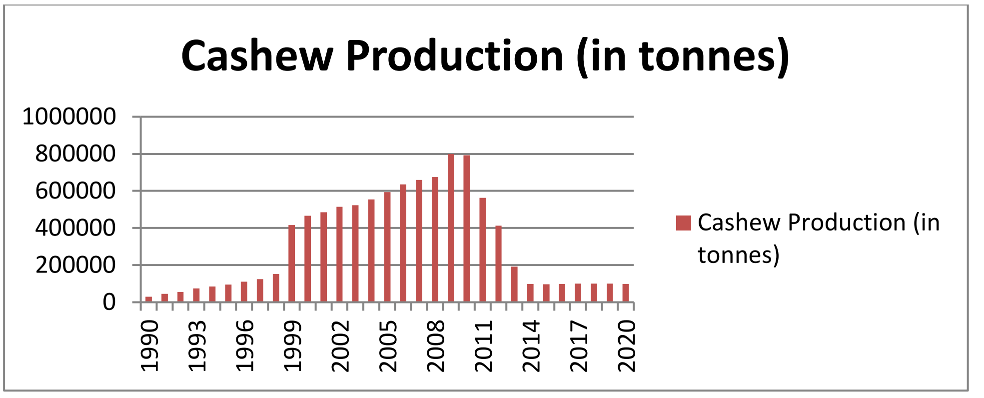
In present day Nigeria, cashew is grown in more than 20 states with majority of the produce coming from Kogi, Anambra, Oyo, Enugu and Osun states (Aremu-Dele *et al*., 2021). The crop has become a crucially important agricultural product for many farming households. It is also the main source of revenue for many farmers and a major export sector of the country. According to Esan *et al*., (2018), cashew exports contribute about 8% to Nigeria's non-oil export earnings this fact is also backed by Ogunwolu *et al*., (2020) which stated that between the periods 2010 to 2014, the crop contributed \$25million to \$35million.

According to Monteiro *et al*., (2017), declining production levels of agricultural commodities have been identified by various authors as a prominent cause of food insecurity in Africa. However, while there is a general agreement on the role of food crops in food security there have been inconclusive reports regarding the role of cash crops such as cashew in food security (Jarzebski *et al*., 2020). Some authors such as Gamborg *et al*., (2012) opined that cash crop production competes with food crop production thereby having an adverse effect on food security; conversely, authors such as Kuma *et al*., (2019) are of the opinion that the cultivation of cash crops increases farmers' incomes thereby improving their ability to access food and satisfy their dietary needs. Cashew not only serves as a cash crop but also as a source of food material for households, cashew nut is widely consumed and is considered as a snack to many, cashew apple can be readily consumed from the point of harvesting, while extracts such as juice and jam are also food items for household consumption (Olife *et al*., 2013). Hence, cashew provides food for farmers and also serves as a source of income as well. This implies that cashew can play an important role in improving the food security status of the country if its production is improved. The contribution of cashew to the agricultural sector and the economy as a whole cannot be overemphasized; hence, the broad objective of the study is to examine the Nigerian cashew industry as it affects food security and agricultural development overtime. The specific objectives are to:

a. Assess the trend of cashew production overtime (1990-2020)
b. identify causes for the trend
c. Proffer solution based on the observed trends perceived challenges

CASHEW PRODUCTION IN NIGERIA

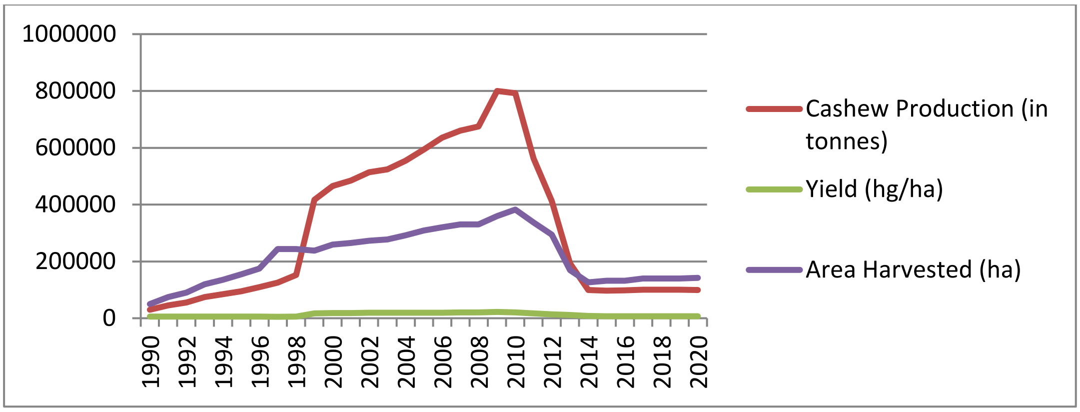
Figure 1 presents an outline of cashew production in Nigeria. The figure reveals that cashew production has been on the rise since the early 1990s: there was a rapid increase in the year 1999 when cashew production increased from 152,000 tonnes in 1998 to 417,000 tonnes – this increase continued until 2009. However, by the year 2011, a rapid drop in production was observed. The drop continued until 2014 when cashew production in Nigeria fell to less than 100,000 tonnes per year. However, cashew production remained relatively stable at 100,000 tonnes from 2016 to 2019 only to fall slightly to 98,800 tonnes in 2020. The fall in cashew production experienced in 2020 may be attributed to the COVID- 19 pandemic which affected agricultural production.



Source: FAOSTAT 2020

Figure 1: Cashew production in Nigeria (1990-2020)

Figure 2 presented cashew production, yield and area harvested in Nigeria (1990-2020)**.** The behaviours exhibited by cashew production in Nigeria over the years are affected by cashew yield and area harvested. This implies that cashew production is directly proportional to the area harvested. Both cashew yield and area harvested were on an upward trajectory between the periods of 1990 to 1998. This may be due to the relative ease in cultivation and the rise in the value of cashew nut in the international market. Cashew yield showed even more promise in the year 1999 when the yield increased by over 60 percent; the growth in cashew yield was steady up till the year 2010. Similarly, area harvested showed a galloping upward trend from 1999 and got to its peak in 2010 after which there was downward trend. This probably may be as a result of renewed interest by farmers to expand their farm holdings or due to the application of good agricultural practices. Kolliesuah *et al.* (2020) attributed the rise in cashew production in the boom years of 1999 to 2009 to increase in harvested area. This conforms to the a priori expectation that an increase in the land used in the cultivation of the crop will normally increase the production levels of a crop all things being equal. According to Adeigbe *et al.* (2015) the decline in cashew production experienced in 2011 to 2014 may be attributed to poor pricing of Nigerian cashew in the international market which is as a result of the compromised cashew quality often affected by poor peel ability and storage. This serves as a form of discouragement for cashew farmers in Nigeria. Uwagboe *et al.* (2010) cited the lack of adequate infrastructure and modern breeding technology as one of the factors militating against cashew production in Nigeria. The relative stability in cashew production from 2014 to 2020 shows that despite the obvious issues confronting cashew production some farmers have refused to be crowded out; also this period coincides with the agitation for the diversification of the Nigerian economy, this may have prevented further decline in cashew production. Cashew yield in Nigeria has been relatively stable overtime showing that the behaviour of cashew production in Nigeria may not be attributed to increase or decrease in cashew yield but rather to changes in the harvested area.



Source: FAOSTAT 2020

Figure 2: The trend of cashew production, yield and area harvested in Nigeria (1990-2020)

CONCLUSION AND RECOMMENDATIONS

The study assessed the trends and challenges of cashew industry in Nigeria from 1976 to 2021. From the foregoing, it has been established that cashew production in Nigeria started declining around 2011 and 2012. Though the production showed slight improvement around 2018, the cashew production sub-sector remains a shadow of its old self as the country has found it difficult to replicate the high production levels witnessed in 2009 and 2010. Literature is not clear about the role of cash crops such as cashew on food security, however, cashew is not just a cash crop, it also serves as a source of food material for households. Hence, the role of cashew in food security in Nigeria could become very vital if production levels are improved upon. This will increase farmers' income thereby improving their ability to afford other food products and also increase the local consumption of cashew.

In order for the country to get back to its glory days as far as cashew production is concerned, it is recommended that cashew farmers, intending farmers and investors be encouraged by the government in the following ways:

- Protecting the value of Nigerian cashew nut in the global market by establishing a standard control agency that will ensure that only quality cashew nuts are exported in order to boost the value of the cashew nuts.
- Massive investment in cashew research as this will provide the scientists with the necessary tools required for the creation of better seedlings, better breeding technology and better pest control and disease prevention mechanisms as this will improve cashew yield.

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Production And Marketing Of Root And Tuber Crops: A Panacea To The Challenges Facing Agricultural Development In Nigeria

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ABSTRACT
There is need for this study to review the production and marketing of root and tuber crops as a remedy to the challenges facing agricultural development in Nigeria. Secondary data were used for the study. Root and tuber crops are staple food crops, being the source of daily carbohydrate intake for the large populace of the world and Nigeria in particular. Some selected root and tuber crops reviewed in this study are cassava, yam, potato, sweet potato and cocoyam. Production and marketing of root and tuber crops challenges include quality seed production, low level of financial base, high cost of labour, new variety adoption, seasonal variations, transportation and storage among others. Notwithstanding the challenges, root and tuber production has been found to be profitable. The study showed that production and marketing of root and tuber crops is important in agricultural development in Nigeria through provision of foods to man and animal feeds, raw materials for industries, income generation for farm families and creation of employment opportunities. It is recommended that farmers should be engaged in production and marketing of root and tuber crops for increased food availability, available raw materials for industries and sustainable income generation and creation of employment opportunities in Nigeria.

Key words: Production, Marketing, Root and Tuber crops, Nigeria.

INTRODUCTION
Agricultural production remains the main source of income for most rural communities (about 86 percent of rural people of about 2.5 billion depend on agriculture for their livelihood) (Nteranya and Adiel, 2015). Nigeria is an agricultural country that is endowed with enormous food and agricultural resources such as yam, cocoa, cassava, rice, sugar cane, maize, and millet (Nahanga and Vera, 2014).
Root and tuber crops comprises of crops covering several genera. They are staple food crops, being the source of daily carbohydrate intake for the large populace of the world. They provide substantial part of the world's food supply and also important source of animal feed and processed products for human consumption and industrial use (Chandrasekara and Kumar, 2016). They are crops grown in varied agro-ecologies and production systems ranging from highland densely populated regions to lowland drier areas prone to droughts or floods. These crops (cassava, yam, cocoyam, potato and sweet potato) account for about 95% of the total root

and tuber crops production in Africa and produce more than 240 million tons annually on 23 million hectares ((Nteranya and Adiel, 2015).
Importance of production and marketing of root and tuber crops in agricultural development of Nigeria cannot be over emphasized. The relative importance of these crops is evident through their annual global production which is approximately 836 million tons (FAO, 2013). Nutritionally, root and tuber crops have a great potential to provide economical source of dietary energy and about one-third of that of an equivalent weight of rice or wheat due to high moisture content (FAO, 1990). Therefore, there is need for this study to review the production and marketing of root and tuber crops as a remedy to the challenges facing agricultural development in Nigeria.

Root and Tuber Crops Production and its Relevance to Agricultural Development
Cassava
Cassava (*Manihot esculenta*) is an important and one of the widely grown staple in Nigeria (Okelola *et al*., 2014). It is very crucial in food economy of the nation, impacting on food and income security of the rural households (Mondo *et al*., 2019). Nigeria produces more than 45 million metric tons (MT) of cassava, thus, emerging as the world's largest producer. About one-third of the total national output comes from the Niger Delta region where many livelihoods depend on cassava as a main source of food and income (Igberi and Awoke, 2013). Global demand for the commodity has been growing significantly over time because of its appeal as a food security crop for growing populations in emerging markets, and the growing demand for industrially processed cassava products (Nteranya and Adiel, 2015). The Global Cassava Development Strategy study commissioned by IFAD and FAO and the Vision 2020 study of the CGIAR on root and tuber crops stressed the great potential of cassava to spur rural industrial development, raise rural incomes, and contribute to food security (Nteranya and Adiel, 2015). Cassava is used mainly for two main purposes in Nigeria: 90% as human food and only 5-10% as secondary industrial material (used mostly as animal feed). About 10% of Nigeria's industrial demand consists of HQCF used in biscuits and confectioneries, dextrin pre-gelled starch for adhesives, starch and hydrolysates for pharmaceuticals produces and as seasonings. Between 70-90% of cassava processed as human food is gari. Other common cassava products for human foods are lafun and fufu/Akpu. Processed products can be classified into primary and secondary products. The primary products are garri, fufu, starch, chips, pellets which are obtained directly from raw cassava roots, while the secondary products are obtained from the further processing of primary products for example, glucose syrup, dextrin, and adhesive are obtained from starch (Nteranya and Adiel, 2015).

Yam
Yam is one of the tuber crops produced in Nigeria and it has many species, of which six are economically important staple species. They are *Dioscorea rotundata* (white guinea yam), *Dioscorea alata* (yellow yam), *Dioscorea bulbifera* (aerial yam), *Dioscorea esculenta* (Chinese yam) and *Dioscorea dumetorum* (trifoliate yam). Out of these, *Dioscorea rotundata* (white yam) and *Dioscorea alata* (water yam) are the most common species found in Nigeria (Anozie *et al.*, 2014). Yams are grown in the coastal region in rain forest, woody savanna and southern savanna agro ecology. In many yam-producing area in Nigeria, it is said that "yam is food and food is yam" (Bolarinwa and Oladeji, 2009). Yam crop forms a staple food for most people of the tropics. Yam tubers are eaten in different forms including eating it boiled, fried, pounded or made into yam powder for fufu. As food crop, the place of yam in the diet of Nigerians cannot be overemphasized. It contributes more than 200 dietary calories daily, for more than 150 million people in West Africa as well as serving as an important source of income (Babaleye, 2003). It is also comparable to any starchy root crops in energy and the

fleshy tuber is one of the main sources of carbohydrates in the diet of most Nigerians (Okpara *et al.*, 2014). Yam also plays vital roles in traditional culture, rituals and religion as well as local commerce of African people (Izekor and Olumese, 2010).

Cocoyam

Cocoyam is an important staple food across many developing countries in Africa, Asia and Pacific (IITA, 2008). It is particularly important in sub-Saharan Africa where the two most commonly cultivated species *Colocasia esculenta* and *Xanthosoma sagittifolium* are grown extensively (Nwadili *et al.,* 2016). Cocoyam plays important roles in the livelihood of rural farmers. In some years back (2008-2012), Africa accounted for 86% of the global area harvested and 74% of total taro production. The west African sub-region alone accounted for 61% of global area harvested and 50% of global production (Okoye *et al.*, 2013). Although, the figures above indicated a decline in the contribution of the region in taro production, this may be attributed to infestation of Taro Leaf Blight (TLB) (Nwadili *et al*., 2016). It is of interest to note that cocoyam among other root and tuber crops such as cassava, sweetpotato and yam is not attacked by goat and sheep and it is edible crop, because the corms and cormels are eaten in various food forms while the leaves and flowers are commonly used as spice to garnish and flavor food (Chukwu, 2011). Cocoyam is adjudged to be nutritionally superior to major competitor roots and tubers in terms of digestibility, contents of crude protein and essential minerals such as Ca, Mg and P. The importance of cocoyam is not only attributed to its use as source of food for man; industrially, cocoyam is used for production of alcohol, medicines, flour, starch and feed for livestock.

Potato

Potato (*Solanum tuberosum* L.) is one of the major tuber crops in Nigeria. The crop is well known for its high nutritional quality; good source of carbohydrate; potassium, vitamin B and C. It is a source of both food and cash income and has been known as one of the major crops to alleviate hunger in the world (Crissman *et al*., 2017). Smallholder farmers in particular are discovering that the potato can help in food security because it is a high yielding cash crop with a short growing season. Highland potato farmers enjoy a comparative advantage in exploiting an ever-growing, high market demand for the crop, as potato production requires the cool temperatures typical of mid- to high altitudes. Furthermore, potato production is important in North Africa, where the crop offers a huge export market to Europe and under irrigation in Harmattan season in the Sahel Zones in West Africa. There are many compelling reasons for encouraging more wide-scale adoption of potato into the livelihoods of Africa smallholder farmers. The crop is short cropping cycle of three to four months is well-suited to the double cropping seasons in the African highlands, particularly in rain-fed systems. Harvestable tubers are available 60-100 days after the onset of the rainy season has a significant advantage over grains, which require six to nine months. This makes potato one of the first crops that can be harvested in any growing season, thus an important crop for the “hunger months” that is, a period of several months between harvests when people lack enough food to satisfy their hunger and meet their basic caloric and nutritional needs (Nteranya and Adiel, 2015). Potato is a cheap but nutritionally rich staple food for the fast growing cities of sub- Saharan Africa, contributing protein, vitamin C, zinc, and iron to the diet. There is a huge opportunity to exploit this largely untapped potential, creating entrepreneurial opportunities for all levels along the seed value chain, with a special focus on women and youth farmers (Nteranya and Adiel, 2015).

Sweet potato

Sweet potato (Ipomoea batata (L) Lam) is an important tropical root crop. It belongs to the morning-glory family known as convolulaceae and is originated from Latin America (Low *et* *al.,* 2009). It ranks second after cassava among the tropical root crops. The crop can be considered promoting nutritional security particularly in agriculturally backward areas. In recent times, the West Africa region has witnessed increase in crop output; sweet potato recorded a positive per capita annual rate of increase in production in sub-Saharan Africa (Ndaula *et al.,* 2020). Nigeria is the third largest producer of sweet potato in the world in terms of quantity, after China and Uganda. The crop can give a cash return in 3.5-4.5 months (Shanhbanden, 2018). Use of sweet potato in poultry and pig farming is very well established. Sweet potato offers a particularly significant potential for increasing food production and income in Nigeria. Sweet potatoes are cooked together with cowpea, lima beans, sesame, millet and/or other root and tuber crops to make a traditional porridge. Sweet potato dough is incorporated with other root and tuber crops to create two staple dishes in the country: fufu, a stiff, gelatinous dough prepared by pounding boiled tuber pieces in a mortar; and amala, a thick porridge that is often served with soup (Kathryn *et al.,* 2012). Most sweet potato farmers sell their sweet potatoes along the roadside or at their nearest semi-urban or urban market.

Marketing of Root and Tuber Crops

Marketing are those business activities associated with the flow of goods and services from production to consumption (Agunannah, Essien and Ewuziem, 2016). The marketing of root and tuber crops begins in the farm with the planning of production which is completed with sale of the crops to the consumers. In recent years, there has been increased exportation of root and tuber crops produce such as gari, yams and sweet potatoes to England and other overseas countries for sale to immigrant populations, as well as becoming a useful source of foreign exchange earnings, the growth of international trade in root and tuber crops increases effective demand for food produce (Nteranya and Adiel, 2015). Another market advantage of these crops is that they are largely traded locally and nationally. The market of root and tuber crops is important in the subsistence strategy of most rural households not only because most of the production resources comes from the market but mostly, it is the only way for producers to sell their product (Alleluyanatha, Asumugha and Mbanaso, 2016). The price of root and tuber crops such as yam and potato have gone up in some markets in Nigeria. For instance, a set of yam which consist of five tubers is sold for ₦6,000 and ₦8,000 depending on the size of the tubers. The same set of yam was sold in 2021 between ₦3,000 and ₦4,000. Also, 50kg bag of cassava root is ₦3,500 and it was sold in 2021 for ₦1,700 or less.

Constraints to Root and Tuber Crops Production and Marketing

Production of root and tuber crops challenges related to quality seed production, low financial base, high cost of labour, new variety adoption, losses due to insects and diseases, low productivity in poor soils, tolerance to stress associated with heat and drought, consumer preferences, and storage of harvested products among others. This is in agreement with the report of Oni (2013), who identified some of the constraints in the agricultural sector that inhibit performance and growth of the sector. Marketing of these crops is beset with a lot of problems, which constitute a bottleneck to the flow of goods and services. According to Alabi and Adebayo (2008), many problems affect agricultural commodity marketing which includes distance, cost of transportation, seasonal variation, storage, processing, grading and communication among others as hindrance to the flow of goods in the Agricultural sector. These problems notwithstanding, root and tuber production has been found to be profitable (Ogbonna, 2007).

CONCLUSION AND RECOMMENDATION

The study therefore, concluded that production and marketing of root and tuber crops is important in agricultural development in Nigeria through provision of foods for man and animal feeds, raw materials for industries and income generation for farm families. It is recommended that farmers should be more engaged in production and marketing of root and tuber crops such as cassava, yam, potato, sweet potato and cocoyam for increased food availability, available raw materials for industries, sustainable income generation and creation of employment opportunities in Nigeria.

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Soil Fertility Management Practices and Productivity of Arable Crop Farmers in Benue State, Nigeria

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ABSTRACT

The study estimated the Total Factor Productivity (TFP) and its determinants among arable crop farmers in Benue State, Nigeria with a view to examining the effect of soil fertility management on their productivity. Data were collected from 175 farmers using three stage sampling technique. Data analyses were carried out using descriptive statistics, Total Factor Productivity and least square regression analysis. Prevalent soil fertility management practices were; application of inorganic fertilizer (18.9%), crop rotation (15.4%), mulching (14.9%), application of organic manure (13.7%), alley cropping (13.0%), bush fallowing (12.6%) and cover cropping (11.5%). Result also indicates that 46.9% of the sampled household heads were productive, i.e. have their productivity value above average across all the soil fertility management categories. Determinants of TFP estimate reveals the following factors as having a significant contribution to productivity at different levels of significance in the study area; age (-1.469), education (0.417), farm size (0.046), alley cropping (.357), crop rotation (.380), application of inorganic fertilizer (.503), mulching (.560) and organic manure (.373). While age impacted negatively on productivity, all others impacted positively on productivity. The study concludes that soil fertility management practices are productivity enhancer. Promoting sustainable soil fertility management practices that are farm or farmer specific is recommended.
Keywords: Arable Crop Farmers, Determinants, Household Heads, Soil Fertility Management and Total Factor Productivity.

INTRODUCTION

Agriculture still remain the mainstay of Nigeria's economy as it accounts for 22.36 percent of National Gross Domestic Product (GDP) and providing livelihoods to approximately 70 percent of the country's active labour force (Bernard & Adenuga, 2017; National Bureau of Statistic [NBS], 2022). Agricultural sector grew at the rate of 4.1 percent in 2016 and it accounted for 75 percent of non-oil exports. To improve the sectorial performance, the Federal Ministry of Agriculture and Rural Development (FMARD) has approved Agriculture Promotion Policy (APP), building on the Agricultural Transformation Agenda (ATA) developed under the administration of President Goodluck Ebele Jonathan. The key themes of this policy are supporting productivity enhancements; crowding in private sector investment and FMARD's institutional realignment with a focus to improving the ease of transacting business in Nigeria's agricultural space (Oredipe, 2017).

Productivity is generally defined as the level of output in relation to levels of resources employed in a given period of time. It is the rates of flow of output when compared to rates of flow of resources such as land inputs used in production (Oyaide, 1994). Poor agricultural productivity and food insecurity are persistent features of many developing countries including Nigeria. Increases in food production in the recent past in Sub-Sahara Africa (SSA) are a result of more land being brought into production rather than higher output per unit area of land (World Fact Book, 2012). With the increasing population, cultivable land is becoming the limiting factor in meeting the growing food demand, implying that farm output growth needs to be achieved through higher productivity (World Bank, 2008).

Soil fertility is the intrinsic ability or capability of the soil to provide plant nutrients and water in adequate amount and when required, for good growth and development of the crops. Soil fertility decline (also described as soil productivity decline) is the deterioration of chemical, physical and biological soil properties and its subsequent reduction in providing the crops with adequate nutrients and water (Agboola, 2001). Good soil fertility management practice helps rejuvenates the soil after each cropping season and also keeps the soil in good shape to support another season, thus, the need for appropriate soil fertility management practices. Soil fertility management practices can be seen as management of the soil to increase the quality and durability of the soil to provide required plant nutrient and water in an attempt to maintain optimum crop productivity (Food and Agriculture Organisation, [FAO] 2001 & Oladipo, et al., 2017). With constant cultivation of the soil to meet the growing demand for food amidst changes in climate and decrease in the ability of the soil to provide the required nutrients for plant, it becomes imperative that appropriate soil management practices are explored to ensure sustainable agricultural production.

Based on this, the objectives of the present study are in three folds. First, to isolate the different soil fertility management practices prevalent among the arable crop farmers in the study area, second, to estimate the productivity of the farming household heads stemming from the different soil fertility management practice most frequently practiced and third, to isolate the determinants of total factor productivity in the study area.

METHODOLOGY

The Study Area

The study was carried out in Benue State, Nigeria. The state which is one of the states that constitute the north-central zone of the country is made up of twenty-three (23) local government areas and shares boundaries with Nassarawa to the north, Taraba to the east, Cross River to the south, Enugun, Ebonyi and Cameroon to the south east, Kogi to the west. The state occupies a land mass of 33,955 square kilometers with an estimated population of 4,253,641 (National Population Commission, [NPC] 2006). The state experiences two (2) distinct seasons; wet and dry with an annual rainfall of between 1250-1750mm while annual temperature ranges between 32-38^{0}c. Inhabitants of the state are predominantly farmers and they cultivate such food crops as yam, rice, cassava, soya beans, groundnut, sweet potatoes, millet and guinea corn while such tree/cash crops like mango, citrus/oranges, pawpaw and pineapple could also be found. Major ethnic groups and tribes in the state are are Tiv and Idoma: others are Igede, Etulo, Jukum, Hausa, Akweya and Nyifon.

Sampling Procedure

The study population was arable crop farmers living in the study area; the data used were collected from the 2020 production season. A three stage sampling technique was used in the study. The first stage was the random selection of four (4) local government areas from the state, the second stage was the random selection of fourteen (14) communities/ villages with probability proportion to the size of the local governments, while the last stage was the selection of farmers from the selected villages/communities based on sampling frame. A total of 200 copies of the questionnaire were administered with only 175 returned with useful information that was used for the analyses as shown in Table 1.

Table 1: Sampling Procedure for the Selection of Farmers.

State	LGAs	Communities	Number of questionnaire administered	Number of questionnaire retrieved
Benue	Buruku	Abwa, Biliji, Mbataase and Mbaya	68	57
	Oju	Obotu,, Oronu-Ainu, Okpoma Ainu, Oyinyi, Iyeche and Uchuo	64	59
	Otukpo	Otukpoicho and Okete	32	29
	Ushongo	Sati ikov and Bilaji Ikom	36	30
			200	175

Source: Field Survey, 2021

Analytical Technique

This study employed a number of analytical tools based on the objectives of the study. The tools include descriptive statistics, total factor productivity and multiple regression. Descriptive Statistics was used to describe the soil fertility management practices using frequency and percentage. Total Factor Productivity Model as employed by Adepoju and Salman (2013) was used to estimate the productivity value of the farming household heads based on the soil fertility management practice most frequently used. Total Factor Productivity (TFP) is a method of calculating agricultural productivity by comparing an index of agricultural inputs to an index of outputs (Jean-Paul, 2009). Total factor productivity is therefore measured as the inverse of unit cost following Key and Mcbride (2003). This is the ratio of outputs in naira value to the total variable cost (TVC) of production. TFP measures that use physical quantities as output measures rather than revenue actually exhibit even more variation than do revenue-based measures as documented in Foster *et al*., (2008). Hsieh *et al*., (2009) also find greater productivity dispersion in the TFP measures that use quantity proxies to measure output.

$$TFP = \frac{Y}{TVC} \qquad \ldots 1$$

Where Y = Output in Naira value in line with Mwuese and Okorji, (2014).

TVC = Total Variable Cost

$$TFP = \frac{Y}{\sum P_i X_i} \quad i = 1, 2, \ldots\ldots n \ldots\ldots 2$$

Where Y = quantity of output in Naira and P_i = unit price of ith variable input and X_i = quantity of ith variable input

The inputs used in line with Fakayode *et al*., (2008) are: cost of labour, cost of planting materials, Cost of inorganic fertilizer, Cost of herbicide and Cost of pesticide. Following Akintayo and Rahji, (2011) to examine the effect of some socio-economic variables as well as soil fertility management practices on the Total Factor Productivity (TFP), the TFP estimate was subjected to ordinary least square regression to obtain the coefficient of multiple determinations (R^2), F- Statistics, standard error and their values. The ordinary least square regression model is a best linear unbiased estimator whose estimate possesses the desirable properties of unbiasedness, efficiency and consistency.

Model Specification

$$Q^* = f(X_1, X_2, X_3, X_4, X_5 \ldots\ldots X_{14}\ .\mu) \ldots\ldots 3$$

Where

Q* = TFP estimate

The Cobb-Douglas production function is specified as:

$$Q_i = A\ \pi_i\ Z_i^{\ bi};\ i = 1, 2, \ldots 14 \ldots\ldots 4$$

The expanded form is:

$$Q_i = A\ Z_1^{\ b1}\ Z_2^{\ b2}\ Z_3^{\ b3}\ Z_4^{\ b4}\ Z_5^{\ b5} \ldots\ldots Z_{14}^{\ b14} e^{ui} \ldots\ldots 5$$

Following Gujarati (2004), the empirical model to be used for this study can be cast in double-log form as follows:

$$\ln Q_i = \ln A + b_1 \ln x_1 + b_2 \ln x_2 + b_3 \ln x_3 + b_4 \ln x_4 + b_5 \ln x_5 \ldots\ldots b_{14} \ln x_{14} + u \ldots\ldots 6$$

Based on the view of Hussain and Perera, (2004) and as adopted by Akintayo and Rahji, (2011), Adepoju and Salman, (2013) the following factors were hypothesized as the determinants of TFP of arable crop farmers in the study area.

x_1 = Age of household heads (years), x_2 Number of years of formal education, x_3 = Household size (number), x_4 = Farming Experience (years) , x_5 = Access to credit(Dummy Variable; Yes = 1 otherwise = 0), x_6 = Farm Size (ha), x_7 = Extension contact (Dummy Variable; Yes = 1 otherwise = 0), Vector of index of soil fertility management practices (Dummy Variable; Yes = 1 otherwise = 0), x_8 = Alley cropping, x_9 = Bush fallowing, x_{10} = Cover cropping, x_{11} = Crop rotation, x_{12} = Application of inorganic fertilizer, x_{13} = Mulching, x_{14} = Application of organic manure

μ = error term which is assumed to be normally distributed and with mean zero and constant variance

RESULTS AND DISCUSSION

Households Soil Fertility Management Practices in the Study Area

Table 2: Households Soil Fertility Management Practices.

Soil Fertility Management Practices	Frequency	%
Organic Manure	24	13.7
Bush Fallowing	22	12.6
Crop Rotation	27	15.4
Inorganic Fertilizer	33	18.9
Alley Cropping	23	13.0
Cover Cropping	20	11.5
Mulching	26	14.9
Total	175	100.00

Source: Field Survey, 2021

Productivity Estimate in the Study Area

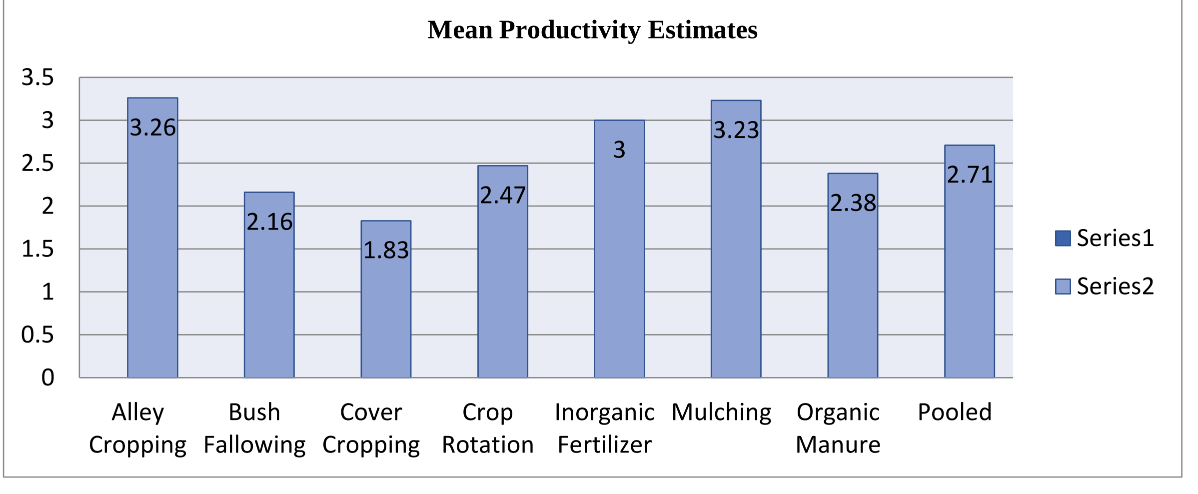

Figure 1: Bar Chart Showing the Mean Productivity Estimates Across the Different Soil Fertility Management Practices in the Study Area
Source: Field Survey, 2021

Factors Affecting Total Factor Productivity (TFP)

As shown in Table 3, the coefficient of determination (R^2) for food crop farmers (0.758) indicates the presence of a high degree of association between productivity (dependent variable) and all independent variables. This implies that 75.8% of the variation in the farmers' productivity is explained by the variations in the independent variables. The F-statistics of the farmers (F-test= 581.71, P<0.001) was found to be highly significant, implying that the independent variables were collectively important in explaining the variation in the dependent one.

Of the fourteen explanatory variables specified, eight were statistically significant. These were age, education, farm size, alley cropping, crop rotation, inorganic fertilizer application, mulching and organic manure application. The negative coefficient ($p<0.01$) of age suggests that farmers were less productive as they age, older farmers are not physically able to produce as much as younger household heads because productivity is countered by declining physical strength and perhaps by negative attitudes toward innovation. The negative coefficient, which implies that a unit increase in farmers' age decrease productivity by 1.46, agrees with the findings of Ahmed and Elrasheed (2016).

Table 3: Factors Affecting Productivity of Food Crop Farming Household Heads in Benue State

Variables	Coefficients	Standard error	T	P> | t |
Age	-1.469	.200	-7.33 ***	0.000
Education	.417	.149	2.80***	0.006
Household size	.006	.015	0.44	0.658
Farming experience	.006	.014	0.46	0.648
Access to credit	.003	.017	0.23	0.820
Farm size	.046	.073	3.35***	0.001
Access to extension	.034	.104	0.33	0.742
Alley cropping	.357	.199	1.79*	0.076
Bush fallowing	.044	.198	0.22	0.824
Cover cropping				
Crop rotation	.380	.193	1.97**	0.051
Inorganic fertilizer	.503	.213	2.36**	0.020
Mulching	.560	.189	2.96***	0.004
Organic manure	.373	.195	1.91*	0.000
Constant	1.055	.937	1.13	0.262
R^2	0.758			
R^{-2}	0.718			
Prob>F	0.0000			

F(13 147)	581.71
N	161

*** 1% significance level; ** 5% significance level; * 10% significance level
Source: Field Survey, 2021

The coefficient of years of education was positive and significant at 1% implying the significant contribution of the variable to productivity. This implies that a unit increase in years of education will tend to increase productivity by 0.417 unit. This is in conformity with the findings by Shittu et al. (2015) who stated that education increases farmers' productivity. The coefficient of farm size was positive and significant at 10% level and implies that a unit increase in farm size will tend to increase productivity by .034. This is likely to be so as farmers with large farms tend to enjoy economies of scale in the purchase of their inputs and sales of their output, thereby reducing the unit cost. The result conforms to the findings by Wawire at al. (2021).

Though not significant, the positive coefficient in respect of household size, farming experience, access to credit and access to extension contact implies that a unit increase in these variables tends to increase productivity by 0.006, 0.006, 0.003 and 0.0034, respectively. In addition, all the soil fertility management practices were positively related to TFP, implying that increased use of any of the management practices led to increased productivity. Although bush fallowing was not significant, alley cropping, crop rotation, inorganic fertilizer application, mulching and organic manure application were significant. The positive and significant value of organic manure is in line with Nuno and Baker (2021).

CONCLUSION AND RECOMMENDATIONS

The result of Total Factor Productivity estimate indicates that arable crop farmers practicing alley farming were the most productive while those practicing cover cropping were least productive. Practicing alley cropping, crop rotation, mulching and application of organic and inorganic fertilizer enhanced arable crop farmers' productivity in Benue State, Nigeria.

- Since age is negatively related to productivity, it is therefore recommended that youth empowerment program in the area should accord priority attention to agriculture so as to further encourage relatively young farmers into arable crop production.
- Education is productivity and soil fertility management enhancing variable since the level of formal education seemed to contribute to the total factor productivity of the farmers. This will not be unexpected as education has a way of helping farmers to reasonably commit their resources to any productive enterprise, resulting in increase in productivity. It is, therefore, recommended that basic education or adult literacy should be encouraged among farmers. There is need to constantly upgrade farmers' knowledge. Access to information on environmentally friendly and soil fertility management practices should be promoted through the provision of informal education for the farmers in the study area.
- Soil fertility management practices are productivity enhancer; the need to promote sustainable Soil fertility management practices that are farm or farmers specific is hereby recommended.

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Constraints to Ginger Production and Consumption in Abia State, Nigeria

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ABSTRACT

The study examined the constraints to ginger production and consumption in Abia state, Nigeria. Using multistage random and purposive sampling techniques 120 respondents were selected from six (6) out of seventeen (17) Local Government Areas. Data were obtained using well-structured questionnaire and were analyzed using descriptive tools such as frequency, percentage, tables and 4- point likert type scale. Result showed that good proportion of the ginger farmers were at their productive age, married and educated. Result also indicated that ginger is consumed in different pattern and that is encouraging. In conclusion, lack of regulated markets, monopoly of the commission agents incidence, among others were they most important constraints to ginger production and consumption in the study area. Sequel to these finding, it is therefore recommended the need to evolve an integrated pest management programme besides strengthening the extension system in imparting knowledge about prevention and control of these diseases since all the farmers expressed incidence of diseases like root rot as one of major problem in ginger cultivation.

Keywords: Ginger, Production, Consumption, Constraints,

INTRODUCTION

Ginger (*Zingiber officinale*) is a rhizome, which consist of numerous short finger-like structures or branches born horizontally near the surface of the soil. Two commercial varieties are commonly cultivated in Nigeria. Ginger is produced in several parts of Nigeria particularly in the Guinea Savanna Zone (southern part of Kaduna State) and to a little extent in Keffi and Akwanga Local Government Areas of Nasarawa State (Dauda and Waziri, 2006). Although ginger has not been commercially recognized globally as functional food, especially from the regulatory/legislative point of view (ESFA, 2016), the many health benefits/ functions of ginger have been documented. Ginger has been used as medicine in Asian, Arabic and Indian herbal tradition since ancient times. Among its health benefits are: maintain normal blood circulation and fight common respiratory problems (Ali *et al.*, 2008), it prevents cold and flu, combats morning and motion sickness (Ryan *et al.*, 2012). It improves absorption and combats stomach discomfort (Ghayur *et al*., 2005), reduces inflammation and can relief menstrual pain

(Ozgoli *et al.,* 2009). Nigeria is one of the leading producers of ginger in the world; her production as in 2013 was estimated at 496 920 tonnes (representing approximately 21 % of the world production) (FAO, 2017).
Nigeria is one of the leading producers of ginger in the world; her production as in 2013 was estimated at 496 920 tonnes (representing approximately 21 % of the world production) (FAO, 2017). Of the total quantity of ginger produced in the country, 10 % is locally consumed as fresh ginger while 90 % is primarily for the export market (FAO, 2010). Nigeria is one of the leading producers of ginger in the world; her production as in 2013 was estimated at 496 920 tonnes (representing approximately 21 % of the world production) (FAO, 2017). Of the total quantity of ginger produced in the country, 10 % is locally consumed as fresh ginger while 90 % is primarily for the export market (FAO, 2010).This study therefore identified the constraints to ginger production and consumption in Abia State, Nigeria with specific objectives on socio-economics status of the respondents and their consumption pattern of ginger.

METHODOLOGY

The study was conducted in Abia state. The population of the study was made up of all ginger producers and consumers in Abia State, Nigeria. Multistage random and purposive sampling techniques were adopted in selecting 120 respondents for the study. In the first stage, two LGAs were randomly selected from each of the Political Zones of Abia State. This gave a total six (6) LGAs. In the second stage, two (2) autonomous communities were randomly selected from each of the 6 LGAs making a total of 12 autonomous communities. The third stage involved a random selection of 10 ginger consuming households in the selected autonomous communities. This made a total of 120 respondent which formed the sample size of the study. The questionnaire were used to elicit information while data realized were analyzed using descriptive tools such as frequency, percentage and tables for objectives 1, 3 and 4- point likert type scale for objectives 2, graded thus: always = 4, sometimes =3, rarely =2 and never =1. The values of the responses were added and further divided by 4 to obtain a mean score of 2.5, which was regarded as mean level of consumption pattern.

RESULT AND DISCUSSION

Some Selected Socio-Economic Characteristics of Respondents

The socio-economic result in Table 1 indicated that a fairly good proportion (37.5%) of the farmers were within the age range of 41 and 50 years while a high proportion (69.2%) of the respondents were married. This result concurs with findings of Ajah, (2013) that rural farmers in South- Eastern Nigeria were married. The result shows that a half (50.0%) of respondents had household size of between 6-10 persons with mean age of 6.0 persons. The implication of this finding is that more family labour would be readily available since relatively large household size is an obvious advantage in terms of farm labour supply, where wage rate is relatively costly. The result implied that moderate proportion (45.0%) of the rural farmers in the study area attended secondary school. It will likely make them more responsive to many agricultural extension programmes and policies. Abudu *et al*., (2014) reported that increase in education of farmers positively influenced adoption of improved agricultural practices. The result showed that a moderate proportion (48.3%) of the respondents had farm size of between 0.6 – 1.0 hectare with a mean farm size of 1.1 hectares. Large farm size increases agricultural productivity and improves farmer's technical, allocative and resource use efficiency as well as enhances access to credit and other farm inputs. The result reveals that majority (78.3%) of the respondents were not members to cooperatives while 21.7% belonged to different cooperative societies.

Table 1: Distribution of respondents according to selected socioeconomic characteristics

Variables	Frequency	Percentages	Mean
Sex			
Male	71	59.2	
Female	49	40.8	
Age (years)			
20-30	15	12.3	
31-40	19	15.8	
41-50	45	37.5	
51-60	27	22.5	
61-70	5	4.16	**42.8 years**
Marital Status			
Single	10	8.33	
Married	83	69.16	
Widow	20	16.66	
Divorce	7	5.38	
Level of Education			
No formal education	11	9.16	
Primary education	35	29.17	
Secondary education	54	45.0	
Tertiary	20	16.67	
Household Size (number of persons)			
2-5	54	45.0	
6-10	60	50.0	
11-15	3	0.25	
16-20	3	0.25	**6.4 persons**
Farm Size (hectares)			
0.1 - 0.5	30	25	
0.6 - 1.0	58	48.3	
1.1 - 1.5	30	25	
1.6 - 2.0	2	1.7	**1.1 hectares**
Cooperative Membership			
Yes	26	21.66	
No	94	78.33	
Total	**120**	**100**	

Source: Field Survey, 2019

Consumption Pattern of Ginger

The result in Table 2 revealed that the consumption patterns of ginger were grinded ($\bar{x}$=3.68), fresh ($\bar{x}$=3.64), fried ($\bar{x}$=3.56), juice ($\bar{x}$=3.21), and dried ($\bar{x}$=2.88). This result implies the respondents consumed ginger in various forms for different reasons.

Table 2: Mean rating of Consumption pattern of ginger in the study area

Consumption pattern of ginger	Always	Sometimes	Rarely	Never	$\sum fx$	$\bar{x}$
Fried	67(268)	53(159)	0(0)	0(0)	427	3.56

Grinded	82(328)	38((114)	0(0)	0(0)	442	3.68
Dried	42(168)	44(132)	12(24)	22(22)	346	2.88
Fresh	77(308)	43(129)	0(0)	0(0)	437	3.64
Juice	60(240)	40(120)	12(24)	8(8)	392	3.27
Grand mean						**3.41**
Benchmark						**2.50**

Source: Field Survey 2020

Constraints to Ginger Production and Consumption

The result revealed that lack of regulated markets (100.0%), monopoly of the commission agents (100.0%), incidence of disease (100.0%), absence of cooperatives (93.3%), lack of reliable source of information (99.2%), severe infestation of weeds (90.0%), and low price at the time of harvest and unnecessary deduction (86.67%), Seed unavailability (85.83%) among others. This result implies that the farmers faced several constraints in the production and consumption of ginger in the study area. Tripathi *et al*. (2006) identified that lack of approach road, monopoly of the commission agents, lack of regulated markets, low price at the time of harvest and unnecessary deduction, absence of cooperatives, limited government intervention in transportation and grading and lack of reliable source of information were the major constraints in the marketing of ginger. Policy options to improve the marketing efficiency and producer's share identified by them were formation of Self Help Groups (SHGs) to take up marketing activities, farmers' co-operatives, establishment of processing units, storage and transportation facilities, regulated markets etc. Efforts at providing cost effective storage facilities will reduce these constraints. Other important constraints are lack of access to credit and unavailability of farm inputs; this is in spite of the earlier finding that access to credit reduced the inefficiency of the farmers. But credit is needed to procure other farm inputs which they claimed was unavailable. Therefore credit plays a very pivotal role if the farmers are to improve their efficiency and operate on the frontier (Ezeagu, 2006).

Table 3: Distribution of respondents based on the constraints to ginger production and consumption

Constraints	Frequency	Percentages
Cost of production	92	76.67
Monolpoy of the commission agents	120	100.0
Lack of regulated markets	120	100.0
Low price at the time of harvest and unnecessary deduction	104	86.67
Absence of cooperatives	112	93.3
Lack of reliable source of information	119	99.2
Severe infestation of weeds,	108	90.00
Seed unavailability	103	85.83
Incidence of diseases	120	100.0

Source: *Field Survey, 2020* ****Multiple responses recorded***

CONCLUSION

The study concluded that good proportion of the ginger farmers were at their productive age, married, educated and had moderate proportion of farm size of between 0.6 – 1.0 hectare with a mean farm size of 1.1 hectares. It was also concluded that a grand mean score of 3.41 which was above the decision mean count of 2.5 indicated that ginger is consumed in different pattern and that is encouraging. In conclusion, lack of regulated markets, monopoly of the commission agents, lack of reliable source of information, absence of cooperatives, lack of reliable source of information, Severe infestation of weeds, low price at the time of harvest and unnecessary deduction among others were they most important constraints to ginger production and consumption in the study area. Sequel to these finding, it is therefore recommended that farmers should form cooperatives to enable them pool their resources together, access markets and command better prices for their products. All the farmers expressed the incidence of diseases like root rot as a major problem in ginger cultivation. Hence, there is an urgent need to evolve an integrated pest management programme besides strengthening the extension system in imparting knowledge about prevention and control of these diseases.

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Ginger (Zingiber officinale) reduces acute chemotherapy-induced nausea: a URCC CCOP study of 576 patients.

Socioeconomic Analysis of Artisanal Fish Production Output in Badagry Local Government Area of Lagos State, Nigeria

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ABSTRACT

This study analyzed the determinants of fish production output in Badagry Local Government area, Lagos State, Nigeria. A two-stage sampling technique was used to elicit information from 120 artisanal fish farmers through the use of a well-structured questionnaire. Data were analyzed using descriptive statistics and multiple regression analysis. Results revealed that majority (61.7%) were male, with a mean age of 44 years. Most (60%) of the respondents had secondary education and 62.5% had a fishing experience of between 6-10 years. Majority (75%) had contact with extension services twice per month and 60% are credit beneficiaries from cooperative society. The mean monthly revenue from fish farming was ₦23,343.17. The regression analysis result showed that artisanal fish production output was significantly influenced at different levels by sex, age, number of boats, fishing experience, credit beneficiary and frequency of extension contact. It was established from the study that artisanal fish farmers that are credit beneficiaries from the cooperative society and also employed more than one boat in fishing have higher fish output than others. The study recommended that credit facilities should be made more available to artisanal fish farmers by relevant stakeholders to enable them increase their production output in order to serve the teeming increasing population.

Keywords: Artisanal, Fish, Output, Production and Socioeconomic.

INTRODUCTION

In Nigeria, the fishery industry is made up of three key sectors which are the aquaculture (fish farms), artisanal (inland rivers, lakes, coastal and brackish water) and industrial fishing. Nigeria is a typical coastal country, with a coastline of around 800 kilometres, a continental shelf of about 256,000 kilometres, an exclusive economic zone of 210,900 kilometres and a marine area of 46,000 kilometres, which can be exploited for fishing. The country also has about 14 million hectares of reservoirs, lakes, ponds and major rivers, which can produce over 980,000 metric tonnes of fish annually (Oladimeji *et al.*, 2013). In Nigeria, artisanal inland fisheries are not only an essential alternative source of animal protein, but also important to the economy, accounting for around 5% of the country's GDP (FDF, 2013). Between 1991 and 2003, inland artisanal fisheries accounted for more than 85% of domestic fish production, with a total fish production of 615, 507metric tonnes in 2007 (Nwabeze and Erie, 2013). Artisanal fishing generates foreign cash for the country, as well as employment, income and raw materials for the livestock feed industry (FAO, 2010). Despite its immense potential, Nigerian fish production is still unable to bridge the gap between total production and total demand. According to statistical data on fish production in Nigeria, production has decreased from 1984 to the present to less than 400,000 metric tonnes, down from 508,000 metric tonnes in 1982. (FDF, 2008). In addition, with increased population and income, there is a very high demand for fish in Nigeria, but there is a substantial shortfall between demand and supply of roughly 0.44 million metric tonnes (FDF, 2008). Furthermore, according to Inoni and Oyaide (2007), the ability of the artisanal fisheries to maintain its function in food provision, employment creation and income generation in the Nigerian economy is centered on the adoption of relevant management techniques that will guaranty their sustainability in the face of intense fishing pressure. The artisanal fishery sector is plague with variety of challenges in spite of it being a vital source of income for the majority of coastal households. Despite various efforts to increase fish production, not much has been done to increase the productivity of artisanal fishing in Lagoon water (Okeowo *et al.*, 2015). Furthermore, there exist little literature on the socioeconomic determinants of artisanal fish production output in Badagry Local Government Area of Lagos State. Therefore, the study examined the socioeconomic determinants of artisanal fish production output in the study area.

METHODOLOGY

The study was conducted in Badagry Local Government Area (LGA) of Lagos State, Nigeria. The respondents were chosen using a two-stage sampling technique. Firstly, out of the 8 fishing sites in the study area, three fishing sites (Alakotomeji, Yevoyan and Aivoji) were purposefully selected due to high concentration of fishing activities in the area. Secondly, fisher folks were selected proportionately to size across the three fishing sites to give a total of 120 fisher folks which was the sampling population for this study.

Data on fisher folks' socio-economics, inputs use and cost, output realized from fish farming and prices were obtained with the aid of a structured questionnaire. Data collected were analyzed using descriptive statistics (frequency counts, percentages and mean) and Ordinary Least Square (OLS) regression analysis.

The model is explicitly stated thus:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . + \beta_7 X_7 + \varepsilon_{it}$$

Where:

Y_i = Fish output (naira)

X_1 = Sex (male =1; 0 otherwise)
X_2 = Age (years)
X_3 = Educational level (number of years spent in school)
X_4 = Number of boats employed in fishing (number)

X_5= Fishing experience (years)
X_6 = Credit beneficiary (beneficiary = 1; 0 otherwise)
X_7 = Frequency of extension contact (number)
ε = Error term

RESULT AND DISCUSSION

Socioeconomic characteristics of artisanal fish farmers

The socioeconomic characteristics of the artisanal fish farmers sampled in the study area are presented in Table 1. Majority (61.7%) of the fisher folks were male while 38.3% were female. This means that artisanal fishing activity is male dominated. This conforms to the earlier documentation of Aminu *et al.*, (2017) on the same subject. More than one-third (37.5%) of the fisher folks were between 40-49 years of age. The average fisher man in the study area is about 44 years old. This implies that majority of the fisher folks are in their active and productive age and therefore best effort can be put in to guarantee optimum output. This further corroborates the findings of Olaoye *et al.*, (2012) and Aminu *et al.*, (2017).

The result further showed that majority (60%) of the fisher folks had secondary education while very few (10%) had non-formal education. In terms of fishing experience, majority (62.5%) of the fisher folks had between 6-10 years fishing experience, 20.8% had between 1-5 years while 16.7% had above 11 years. This suggests that a small proportion of the fisher folks were relatively new in the business. This is in tandem with the earlier report as opined by Olaoye *et al.*, (2012), who found that fishing experience is important in determining the output levels of artisanal fisher folks, the more the experience, the more fisher folks understand the fishing environment, conditions, patterns, styles, trends, terrains and prices. Some (38.3%) of the artisanal fisher folks had 3 boats for fishing, 25% had 2 boats while 36.7% had just one boat. Also, as shown in the table, 60% of the artisanal fisher folks were credit beneficiaries from the cooperative society while very few (40%) were non-beneficiaries. This could enhance and improve their output. Fish output in naira showed that a large number (66.7%) of the fisher folks realized between ₦10,000 and ₦ 50,000 on a monthly basis, 25.8% realized below ₦10,0000 while just very few (7.5%) realized above ₦ 50,000.

Table 1: Socioeconomic Characteristics of Artisanal Fish Farmers in the Study Area

Variables	Frequency	Percentage	Mean
Sex			
Male	74	61.7	
Female	46	38.3	
Age (years)			
30-39	39	32.5	
40-49	45	37.5	
50-59	29	24.2	
60 and above	7	5.8	44.4
Educational qualification			
Non-formal	12	10.0	
Primary	36	30.0	
Secondary	72	60.0	
Fishing experience (years)			
1-5	25	20.8	
6-10	75	62.5	
11 and above	20	16.7	8.1

Number of boats			
1	44	36.7	
2	30	25.0	
3	46	38.3	2.0
Frequency of extension contact (per month)			
Once	20	16.7	
Twice	90	75.0	
Thrice	10	8.3	1.9
Credit beneficiaries			
Yes	72	60.0	
No	48	40.0	
Fish output (naira)			
Below 10,000	31	25.8	
10,000-50,000	80	66.7	
Above 50,000	9	7.5	23,343.17

Source: Field Survey, 2021

Ordinary Least Square Regression Analysis of the Socioeconomic Determinants of Artisanal Fish Production Output

The socioeconomic drivers of fish production output in the study area was investigated using Ordinary Least Square regression analysis. Table 2 showed that six explanatory variables (sex, age, number of boats, fishing experience, credit beneficiary and frequency of extension contact) are significant factors impacting fish production output at various probability levels. The diagnostic statistics revealed that the model is correctly fitted. The co-efficient of multiple determination, R^2 value of 0.641, revealed that the explanatory factors (sex, age, number of boats, fishing experience, credit beneficiary and frequency of extension contact) explained 64.1 percent of the variation in fish production output. The obtained coefficients are consistent with the *a priori* expectations. The F-ratio was 9.20 and statistically significant at 1%.

The coefficient of fisher folks' sex (X_1) is positive and significant at 5%. This means that fish output from male fisher folks were much higher than the female fisher folks. Age of the fisher folks (X_2) is positive and statistically significant at 10%. This implies that as their age increases, the output from fish catch also increases possibly due to perfection in fishing activities. Specifically, a unit increase in the age of the fisher folk will increase fish production output in the study area by 23.2%. This agrees with the earlier submission of Ifejika *et al.*, (2007); Onyenweaku *et al.*, (2010) and Oke *et al.*, (2021) who submitted that productivity increases with age possibly due to accumulated knowledge and experience gathered from years of observations and experimentations with various production technologies. Number of boats (X_4) is statistically significant at 1% but also has a positive relationship with fish output. This suggests that the higher the number of boats, the higher the fish output. Specifically, an additional boat usage in fishing will increase fish output by 81.5% in the study area. Fishing experience coefficient (X_5) is positive and significant at 10%. This suggests that the more experienced the fisher folks, the more the fish output. This may probably be due to the fact that perfection sets in with repetition of fishing activities over time. This results further agrees with the earlier submission of Oyinbo *et al.*, (2016) that experience positively influence farmers output. Credit beneficiary (X_6) was positive and statistically significant at 1%. The positive relationship observed also conforms to the *a priori* expectation. This implies that fisher folks who benefitted from credit facilities from the cooperative society had higher output levels than those who did not. Specifically, credit facilities will increase fish output level among the fisher folks in the study area by 53.3%. This corroborates the earlier findings of Chikezie *et al.*, (2012) and Onyekuru *et al.*, (2019) who submitted that credit play an important role in agribusiness activities and positively influence output level and its absence affect economic returns. Frequency of extension contact coefficient (X_7) was significant at 10% and had a positive relationship with fish output level in the study area.

Table 2: OLS Regression Analysis Result of the Determinants of Artisanal Fish Production Output in Badagry Local Government Area

Variables		Co-efficient	t-value
Sex	X_1	0.178	1.96**
Age	X_2	0.232	1.93*
Educational level	X_3	1.070	1.49
Number of boats	X_4	0.815	17.72***
Fishing experience	X_5	0.533	1.71*
Credit beneficiary	X_6	0.684	9.24***
Frequency of extension contact	X_7	0.200	1.90*
Constant		59327.79	2.38
Number of observation		120	
R^2		0.641	
Adjusted R^2		0.639	
F-ratio		9.20	

Source: Computed from Field Survey, 2021
***, ** and * denote significance at 1%, 5% and 10% probability levels respectively.

CONCLUSION

The study concluded that sex, age, number of boats, fishing experience, credit facilities, and frequency of extension contact had statistically significant influence on artisanal fish catch level in the study area. As a result, the study recommended that credit facilities be made more accessible to artisanal fish farmers by relevant stakeholders in order for them to increase their production output so as to serve the rapidly growing population.

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Impacts of coronavirus on food systems in Ikwerre Local Government Area of Rivers State, Nigeria

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ABSTRACT

Coronavirus pandemic is putting diets, food systems and agricultural production in jeopardy globally, with agricultural trade and value chains out of reach for masses. Therefore, this study analyzed the impact of coronavirus on food systems in Ikwerre LGA of Rivers State, Nigeria. Data were analyzed using descriptive statistics. The result of the socio-economic descriptions shows that majority (78.9%) of the farmers were married, and 71.9% indicated no interest in any farmers' association. Also, the result shows that majority (96.5%) of the farmers were aware of coronavirus pandemic, and 52.6% agreed that farmers were vulnerable to coronavirus. The study recommended that farming inputs should be subsidized and agricultural produce markets reorganized. Also, storage facilities should be made available in rural areas.

Keywords: *Coronavirus, food systems, distributions, vulnerability, sustainability*

INTRODUCTION

Food is indispensable and essential for human growth and well-being. Crop planting, hunting, fishing and other agricultural related activities have always been occupations that provide livelihood for majority of the rural populace. With job diversification and urbanization on the rise, agricultural activities have also become important sources of income, alongside food processing and marketing that have improved to feed cities (Dury, Bendjebbar, Hainzelin, Giordano & Bricas, 2019). Food systems means the chains of market and non-market operations and actors relating to food production, aggregation, transportation and storage, processing and catering, distribution, preparation and consumption, waste and resource management, agro-input suppliers (seeds, fertilizers, improved livestock) and the associated regulatory activities (Food and Agriculture Organization FAO, 2018). Abundant food alone does not guarantee food security as food availability are influenced by food supply and demand, food accessibility and affordability which are key drivers of food security. As a result, food systems are strategic in contributing to food security and social impacts (Dury *et al.*, 2019). FAO (2017), classified food systems into three focus areas which objectively address global food concerns in keeping with social implications. They are: food security and improved nutrition; inclusive development; creation of a sustainable environment and the fight against climate change.

Socio-economic trends are key drivers of the Nigerian food system. Nigeria is facing major challenges with high population growth, high number of people living in extreme poverty, rapid urbanization, and stagnating agricultural productivity. Public investments in the agricultural sector are low, resulting in underdeveloped (especially rural areas) infrastructure (roads, storage and processing facilities) as well as insufficient agricultural services such as advisory services, access to inputs and finance (Posthumus, Dengerink, Dhamankar, Plaisier & Baltissen, 2020). Due to the inadequate investment which resulted in low productivity, Nigeria is deficit in food production. The high urban demand is met through cheap food imports, which further lowers the incentives for investments in Nigerian agriculture. As such, the shortfalls in food supply at many levels seem to be enabling poverty by reinforcing increased demand for food. Environmental trends, such as soil degradation, climate change, water scarcity, deforestation and decreasing biodiversity pose further threats to the food system, as well as current pandemic of coronavirus. The novel coronavirus increasingly illuminates a serious underlying instability that goes beyond health. This instability stems from the fact that health, energy, finance, and food systems are all inextricably linked.

The spread of COVID-19 globally will compound pressures on food systems. Consumer access to food and producer access to markets could be impacted significantly. In Nigeria, especially Ikwerre Local Government Area of Rivers State Nigeria, the virus could take a significant toll on food production should it affect the aging agricultural workforce who are more vulnerable to it and/or prevent women and rural dwellers (who produce almost 70% of Nigeria's food) from farming. To this end this study examined the impacts of coronavirus on food systems in Ikwerre Local Government Area of Rivers State, Nigeria. The specific objectives of the study were to: describe the socio-economic characteristics of farmers in the study area; ascertain the influence of coronavirus on food production and distribution channels in the study area; determine the factors affecting food systems sustainability in the study area.

MATERIALS AND METHODS

The study was conducted in Ikwerre LGA in Rivers State, Nigeria. It is located between latitudes 4º58′10′′N and 5º14′30′′N, and longitudes 6º49′0′′E and 7º0′0′′E. It covers an area of about 655km^2 with projected population of 265,400 by 2021 (National Bureau of Statistics NBS, 2022). The Ikwerre LGA has ten (10) districts. namely Aluu, Elele, Igwurita, Isiokpor, Omogwa, Omadema, Omerelu, Ozuoba, Ubima, and Umuanwa.

Multistage sampling procedure was used to select the farmers for the study. Stage one was a random selection of four (4) districts. Stage two involves random selection of three (3) communities from each district, making twelve (12) communities. Lastly, nine (9) farmers were purposively selected from each community, this purposive selection was due to restriction on the movement during the period of data collection making a total of one hundred and eight (108) farmers of which eighty (80) were retrieved for the study. The data for the study were collected from primary source with the aid of questionnaire and interview schedule. Secondary sources include articles, journals, internet and review of books to provide the needed theoretical background for this study. Data were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Table 1: Socio-economic characteristics of the farmers

Variables	Mean	Minimum	Maximum
Age (Years)	41.61	17	65
Years spent in formal education	11.26	0	22

Household size	6	1	15
Farmers' household distance to the farm (km)	1.6	0	10
Farming experience	15.14	2	50
Crop farm size (ha)	0.85	0.1	3
Livestock size (number)	400	2	2500

Source: Field survey, 2020.

Table 1 shows that the farmers mean age (42 years) is within productive age. The farmers indicated sufficient number of years spent in formal education (11 years); which implies that they could read and write and are capable of keeping farm records. The farmers have adequate farming experience (15 years); crops and livestock were being produced at subsistence scale which could be made worse by the COVID-19 pandemic. Awareness of coronavirus by the farmers in the study area indicated that majority (96.3%) of the farmers were aware of coronavirus while about 60% attested to the vulnerability to coronavirus. This presupposes that the farmers could mitigate the effect of coronavirus in their production system.

Table 2: Effect of coronavirus on food production and distribution channel

Effect of coronavirus	SA		A		D		SD			
Variables	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	$\bar{X}$	**Rank**
Insufficient access to capital due to restriction in banks and crowd	26	32.5	29	36.3	13	16.3	12	15	2.1	1^{st}
Border closures due to inter-state transportation	27	33.8	27	33.8	14	17.5	12	15	2.1	1^{st}
Perishability of most agricultural produce	31	38.8	25	31.3	13	16.3	11	13.8	2.1	1^{st}
Increase in cost of farming inputs	26	32.5	29	36.3	9	11.2	16	20	2.2	2^{nd}
Markets closures	26	32.5	26	32.5	14	17.5	14	17.5	2.2	2^{nd}
Trade restrictions imposed on exporters	28	35	21	26.3	17	21.3	14	17.5	2.2	2^{nd}
Reduction in incomes of the farmers	28	35	27	33.8	10	12.5	15	18.8	2.2	2^{nd}
Poor access to Medicare even after been infected	25	31.3	28	35	15	18.8	12	15	2.2	2^{nd}
Unable to purchase at the farm gate	19	23.8	29	36.3	21	26.3	11	13.8	2.3	3^{rd}
Spoilage of food as a result of prolonged storage	25	31.3	25	31.3	15	18.7	15	18.7	2.3	3^{rd}
Less diversity of food options available	19	23.8	30	37.5	17	21.3	14	17.5	2.3	3^{rd}
Labour shortage/supply	21	26.3	27	33.8	16	20	16	20	2.3	3^{rd}
Insufficient access to information on coronavirus	21	26.3	26	32.5	15	18.8	18	22.5	2.4	4^{th}
Farmers vulnerability to coronavirus due to age and other ailments	17	21.3	28	35	17	21.2	18	22.5	2.4	4^{th}
Inability to hire farm labour due to social distancing	19	32.5	26	36.3	13	16.3	12	15	2.4	4^{th}
Poor Government response to coronavirus pandemic	21	26.3	22	27.5	18	22.5	19	23.8	2.4	4^{th}
Volatile staple food price	14	17.5	30	37.5	24	30	12	15	2.4	4^{th}
Unavailability of food	17	21.3	29	36.3	19	23.8	15	18.8	2.4	4^{th}
Forced displacement/migration of people	21	26.3	25	31.3	17	21.3	17	21.3	2.4	4^{th}

Supply chains restriction due to quarantines	14	17.5	28	35	24	30	14	17.5	2.5	5th
Reduced food security	19	23.8	22	27.5	21	26.3	18	22.5	2.5	5th
Unsafe foods	13	16.3	27	33.8	21	26.3	19	23.8	2.6	6th
Threat to improved food nutrition	11	13.8	30	37.5	23	28.8	16	20	2.6	6th

$\bar{X}$ – mean; F – frequency; SA – strongly agree; A – agree; D – disagree; and SD – strongly disagree.
Source: Field survey, 2020.

Table 2 shows the effects of coronavirus on food production and distribution channel. Insufficient access to capital due to restriction in banks and crowd, border closures due to inter-state transportation, perishability of most agricultural produce, increase in cost of farming inputs, trade restrictions imposed on exporters, reduction in incomes of the farmers and poor access to Medicare even after been infected were rated highest among the factors that affect food production and distribution. While threat to improved food nutrition, unsafe foods, reduced food security and supply chains restriction due to quarantines were ranked lowest among the factors that affect food production and distribution. This implies that coronavirus could compound the pressures on food systems, as all the actors along the food value chain could be affected in different ways. This finding agrees with FAO (2019) which stated that coronavirus pandemic is capable of disrupting the global food system.

Table 3: Control measures adopted in the community against coronavirus pandemic in the study area

Variables	Frequency	Percentage
Road blockage		
Adopted	48	60.0
Not adopted	32	40.0
Quarantine		
Adopted	53	66.3
Not adopted	27	33.7
Disruption and closure of market		
Adopted	59	73.8
Not adopted	21	26.2
Washing of hands		
Adopted	71	88.8
Not adopted	9	11.2
Use of face/nose mask		
Adopted	71	88.8
Not adopted	9	11.2
Community sensitization and campaign		
Adopted	38	47.5
Not adopted	42	52.5
Total	80	100

Source: Field survey, 2020.

Table 3 shows the control measures adopted during the pandemic of coronavirus. The strategies adopted for improving food system amidst coronavirus pandemic include; relocation of market (51.3%); mobile buying and selling (40%); use of mobile money transfer (40%); house-to-house selling (61.3%) and online platforms (social media) (47.5%) of the farmers.

CONCLUSION AND RECOMMENDATIONS

The impacts of coronavirus on food systems in Ikwerre LGA of Rivers State, Nigeria induced serious threats on food systems especially in the area of security, stability, accessibility, and distribution. Coronavirus with its hampering effects is capable of slipping Nigeria into deeper crisis of food insecurity and resource scarcity, thereby reducing the chances of being food sufficient as a nation. The study therefore recommended that: storage facilities should be made available even in rural areas where most of the foods are coming from to reduce the incidence of food spoilage; farming inputs should be subsidized for the farmers and agricultural produce markets for each commodity should be reorganized; there should be policies along the food supply chain which include: production, storage, processing, transportation, and purchasing activities to minimize food insecurity, malnutrition and famine; research should be developed and funded to undertake potential impacts on food system actors and their interconnecting risks; food processing machineries and equipment should be made available to counter the labour problems.

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Utilization of Information and Communication Technology (ICT) in Enhancing Cassava Production in Oyo State

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ABSTRACT
The study assessed the utilization of Information and Communication Technology (ICT) in enhancing Cassava production in Oyo State Nigeria. Multi stage and simple random sampling techniques were used to select 120 respondents for the study. Interview schedule was used to retrieve data from the respondents. Descriptive analysis was used to describe socio-economic characteristics of the respondents. The inferential statistics (Chi-square) was used to test the hypothesis. The results showed that the majority (90.8%) of the respondents were married and with the Mean age of 39.1 years. All the respondents (100%) made use of at least one type of ICT to acquire information on cassava production activities. The type of ICT utilized mostly and regularly by the respondents in enhancing cassava production included; Mobile phone ($\bar{x}$ =3.85), Radio ($\bar{x}$ =3.39), Television ($\bar{x}$=3.15) while Poster/print media ($\bar{x}$ =3.11), Computer ($\bar{x}$ =2.82) and Internet ($\bar{x}$=2.56) were either occasionally or not utilized at all. Constraints to the use of ICT for cassava production were; network failure ($\bar{x}$=4.73), infrastructural problem ($\bar{x}$=4.09), interest of the farmers ($\bar{x}$=4.08), literacy level of the farmers ($\bar{x}$=4.06), availability of the resources ($\bar{x}$=3.79), awareness of ICT amongst cassava farmers ($\bar{x}$=3.71) and problem of technical skill ($\bar{x}$=3.69). It was recommended that agricultural extension agents should facilitate workshops where cassava farmers will be developed in ICT skills for their production.

INTRODUCTION
Apart from petroleum, agriculture plays prominent roles in Nigeria's economy. It Provides employment and alleviates poverty in youths and adults in most developed and developing countries. Still, it faces some serious challenges, such as poor communication, climate change and continued deficiencies in infrastructure in rural areas (Adebayo, 2015). However, adequate dissemination of detailed information is a necessary condition for improvement of all areas of agriculture (Fors and Merno, 2020). Thus, Information and Communication Technology (ICT) have been found to increase productivity and output, reduce cost of transportation among other benefits. Small scale farmers who dominate the landscape of developing countries need to

improve farming by acquiring adequate knowledge and information. ICT is an incorporated system which entails the use of computers, mobile communication gadgets, television, radios and satellite imagery equipment (Gelb and Parkers, 2006). ICT has proven to increase agricultural output by improving product quality, provision of full information for product pricing, enabling the collection of agricultural data more efficiently, improving soil testing techniques, improving marketing (e-commerce), easy sorting and record keeping, and so on. Ortmann (2002) opined that the use of ICT is becoming popular as more and more farmers are no longer interested in the traditional ways of keeping farm data and records because they are relatively simple to use and satisfy the recording and information requirement of many farmers. Farmers need different types of information during each stage of production, ranging from weather forecast, pest attack, input, improved cultivation practice, pest and disease management and prices (Jorge, 2002). Inaccessibility of most farmers to ICT had led to low productivity of output. The observed trend therefore necessitated the need for this research work. Hence, general objective of the study was to assess the use of Information and Communication Technology (ICT) in enhancing cassava production in Oyo State while specific objectives were to identify the socio-economic characteristics of the respondents, identify the type of ICT utilized by the cassava farmers in enhancing their production in the study area, examine perceived effect of Information and Communication Technology (ICT) utilization on cassava production and identify constraints to the use of ICT in cassava production in the study area.

METHODOLOGY

The study was carried out in Oyo State, Nigeria. Population of the study comprised of cassava farmers in Oyo State. Multi stage and simple random sampling techniques were used in selecting respondents in the study area. Data were collected from the respondents using interview schedule. The data collected were subjected to descriptive statistics such as frequency and percentage. The inferential statistics (Chi-square) was used to test the hypothesis. Oyo State Agricultural Development Programme (OYSADEP)'s zones such as Ibadan/Ibarapa, Ogbomoso, Oke ogun and Oyo were identified and selected (stage 1). Local governments in each of the agricultural zones were identified and listed (stage 2). 25% of the Local Government were randomly selected in each of the zones (stage 3) while simple random technique was used to select 120 respondents from the local governments selected in stage 3.

RESULTS AND DISCUSSION

Socio economic characteristics of the respondents

Table 1 shows that the mean age of the cassava farmers was 39.1 years. This shows that respondents who make use of ICT in cassava production were still active. This fell in line with the finding of Olise (2010) that young people participate more in ICT driven agriculture. Majority (90.8%) of the respondents are male while 9.2% are female. Majority of the respondents (91.7%) are married, 3.3% are single, 4.2% are widowed and 0.8% are divorced. This shows that matured and responsible respondents are engaged in the use of ICT for cassava production. The Mean household size was 7. This is a good source of cheap and affordable farm labour. Most of the respondents (74.2%) had between secondary and tertiary education. Education is a very vital tool in decision making which influences farm productivity as regards perception and adoption of innovation. This agrees with Ramli *et al.* (2013) findings that educational level enhances efficiency of farmers. The average annual income of the respondents was ₦862,851.44.

Table 1: Distribution of the respondents according to socio economic characteristics

Variable	Frequency (N=120)	Percentage %	Mean
Age			

20-30	31	25.8	
31-40	52	43.4	39.1
41-50	30	25.0	
51 and above	7	5.8	
Sex			
Male	109	90.8	
Female	11	9.2	
Marital Status			
Single	4	3.3	
Married	110	91.7	
Widowed	5	4.2	
Divorced	1	0.8	
Household Size			
1-5	41	34.2	
6-10	69	57.5	
11-15	10	8.3	
Educational Level			
Primary Education	31	25.8	
Secondary Education	79	65.8	
Tertiary Education	10	84.	
Annual Income (₦)			
Less than 500,000	13	10.8	
500,000-1,000,000	98	81.7	862,851.44
1,000,000 and above	9	7.5	

Source: Field survey 2021

ICT utilized in enhancing cassava production;

Based on ranking, Table 2 reveals the ICT utilized by the respondents in enhancing cassava production in the study area. These include: Mobile phone ($\bar{x}$ =3.85), Radio ($\bar{x}$ =3.39), Television ($\bar{x}$=3.15), Poster/print media ($\bar{x}$ =3.11), Computer ($\bar{x}$ =2.82) and Internet ($\bar{x}$=2.56). This implies that majority of the respondents preferred mostly, the use of mobile phone to get agricultural information while the Internet is the least utilized by the respondents in the study area. According to the respondents, mobile phones have enhanced their ability to assess different agricultural information and group discussions. This was in agreement with Seyed and Seyed (2012) that most of the farmers made use of mobile phone, radio, television among others in agricultural activities.

Table 2: ICT utilized in enhancing cassava production in the study area.

Variable	SA	A	SD	D	U	Mean	Ranking
Mobile phone	106(88.4)	11(9.1)	_	3(2.5)	_	3.85	1st
Radio	24(20.0)	56(46.7)	2(1.7)	21(17.5)	17(14.1)	3.39	2nd
Television	21(17.5)	41(34.2)	10(8.3)	40(33.3)	8(6.7)	3.15	3rd
Poster/print media	10(8.3)	56(46.7)	_	48(40.0)	06(5.0)	3.11	4th
Computer	11(9.2)	18(15.0)	21(17.5)	60(50.0)	10(8.3)	2.82	5th
Internet	10(8.3)	11(9.2)	17(14.2)	61(50.8)	21(17.5)	2.56	6th

Source: Computation from field survey, 2021

Level of Utilization of ICT for Cassava Production: Table 3 shows that mobile phone, Radio and Television were the mostly and regularly utilized ICT for cassava production while poster/print media, Computer and Internet were either occasionally or never utilized in the study area.

Table 3: Level of utilization of ICT for cassava production

Variables	Regularly	Moderately	Occasionally	Never	Mean	Rank
Mobile phone	92	16	10	02	2.65	1st
Radio	87	24	08	01	2.64	2nd
Television	62	21	28	09	2.1	3rd
Poster/print media	35	15	42	28	1.5	4th
Computer	12	05	16	87	0.52	6th
Internet	10	07	22	81	0.55	5th

Source: Field survey, 2021

Perceived effect of ICT utilization on cassava production

Table 3 reveals the perceived effect of ICT utilization on cassava production. Most of the perceived effects according to the respondents were: easy access to various technology ($\bar{x} = 4.36$), easy contact between farmers and buyers ($\bar{x} = 4.25$), exchanging of information among the respondents ($\bar{x} = 4.19$), inter-personal relationship between the farmers and extension agent ($\bar{x} = 4.17$), enhancement of strong social cohesion between the farmers and the consumers ($\bar{x} = 4.14$), information obtained from ICT increased the source of income of the farmer ($\bar{x} = 3.99$), and it enable the farmers to get in touch with fellows farmers ($\bar{x} =3.88$). This implies that ICT played a great role in cassava production in the study area. This result is in consonant with Seyed and Seyed (2012), that the role of ICT in agricultural production can't be over emphasized.

Table 3: Perceived effect of ICT utilization on cassava production in the study area.

Variable	SA	A	SD	D	U	Mean	Rank
Access to various technolies.	41(34.2)	74(61.7)	_	3(2.5)	2(1.6)	4.36	1st
Easy contact between farmers and buyers.	56(46.7)	47(39.2)	5(4.2)	8(6.7)	4(3.2)	4.25	2nd
Exchange of information among farmers.	50(41.7)	58(48.3)	_	2(1.7)	10(8.3)	4.19	3rd
Promote interpersonal relationships between the farmers and extension agents.	54(45.0)	52(43.3)	_	3(2.5)	11(9.2)	4.17	4th
Enhance strong social cohesion between the farmers and consumers	31(25.8)	45(37.5)	_	_	44(36.7)	4.14	5th
Information obtained from ICT increases the source of income of the farmers.	14(11.7)	44(36.7)	_	_	62(51.6)	3.99	6th
Easy to get in touch with fellows farmers.	26(21.7)	40(33.3)	2(1.7)	1(0.8)	51(42.5)	3.88	7th

Source: Field survey 2021

Constraints to the use of ICT for cassava production in the study area

Table 4 revealed the factors that hinder the use of ICT for cassava production in the study area. The factors as exposed by the Mean were: Bad net work ($\bar{x}$=4.73), infrastructural problem

($\bar{x}$=4.09), interest of the farmers ($\bar{x}$=4.08), literacy level of the farmers ($\bar{x}$=4.06), availability of the resources ($\bar{x}$=3.79), awareness of ICT among the farmers ($\bar{x}$=3.71) and technical skill problem ($\bar{x}$=3.69). The findings were in line with the work of Adebayo (2015) that various factors hinder the use of ICT in cassava production.

Table 4: Constraints to the use of ICT for cassava production in the study area

Variable	SA	A	SD	D	U	Mean	Ranking
Bad network	77(64.2)	42(35.0)	_	_	1(0.8)	4.73	1st
Infrastructural problem	36(30.0)	69(57.5)	_	7(5.8)	8(6.7)	4.09	2nd
Interest of the farmers.	45(37.5)	60(50.0)	_	4(3.3)	11(9.2)	4.08	3rd
Literacy level of the farmers.	43(35.8)	53(44.2)	2(1.7)	9(7.5)	13(10.8)	4.06	4th
Availability of the resources	25(20.8)	53(44.2)	_	7(5.8)	35(29.2)	3.79	5th
Awareness of ICT among the farmers	35(29.1)	43(35.8)	5(4.2)	14(11.7)	23(19.2)	3.71	6th
Technical skill problem	32(26.7)	38(31.7)	_	9(7.5)	41(34.1)	3.69	7th

Source: Field survey 2021

Relationship between selected socio economics characteristics of the respondents and the use of ICT

Chi-square analysis results as indicated in the Table 5 shows that sex (x^2= 0.000), marital status(x^2 = 0.000) and educational level (x^2= 0.000) had a significant relationship with the use of ICT in the study area. This indicated that sex has relationship with the use of ICT. Education had a positive and significant impact on farmers adoption of new innovation. Marital status determines the social life of the respondents.

Table 5: Relationship between selected socio economics characteristics of the respondents and the use of ICT

Variable	X	Df	P-value	Remark
Sex	73.422	1	0.000	S
Marital	285.21	3	0.000	S
Educational Level	24.136	2	0.000	S

Source: Field survey, 2021 p-value = $\leq$ 0.005 S = significance NS = No significance

CONCLUSION

Based on the result of the study, it can be concluded that majority of the respondents used ICT to enhance cassava production and mobile phone, radio and television were the type of ICT mostly used. In view of the findings, the followings were recommended.

(i) The government should provide social amenities in the rural area such as electricity which will motivate the farmers to use ICT.
(ii) Agricultural extension agents should facilitate workshops where cassava farmers will be developed in ICT skills for their production.
(iii) The government should encourage software developers to reduce taxes paid by them so that suitable packages will be developed for agricultural productions.
(iv) The existing communication equipment should be upgraded by the Government and the concerned industries to ensure better cell phone and internet coverage.

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Economic assessment of disease-free seed yam production using temporary immersion bioreactors: a panacea for clean seed yam agribusiness enterprise.

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ABSTRACT

Farmers especially yam producers are constrained by the availability of high-quality seed yam of improved genotypes. Temporary Immersion Bioreactor System (TIBS) is an advanced method of tissue culture used in raising virus- free clean yam plantlets. This production process will help make adequate clean planting materials available to seed companies. However, the economic status of this seed yam production enterprise is yet to be established. This study was aimed at assessing the economics of seed yam plantlets produced through TIBS for sustained seed yam production business in Nigeria. Through specifically estimating the production level, costs, benefit and profitability of yam plantlet produced from this enterprise. Data for the study was collected from National Root Crops Research Institute (NRCRI) tissue culture laboratory under the project of Yam Improvement for Income and Food Security in West Africa (YIIFSWA) sponsored by Bill and Melinda Gate Foundation. Data on fixed cost, variable cost and production volume was collected during 2020-2021 production period. The results showed that about 21,797 plantlets were produced within period under review. The sum of N4,395,629.46 (USD 10,579.132) was the total cost of production while the net profit of N3,887,230.54 (USD 9,355.548) was gotten. The production of yam plantlets in temporary immersion bioreactor should be considered a good business as it has shown evidence of good returns. This production process should be supported by both the public and private sector in other to promote availability of disease-free breeders' seed.

Key Words: Seed Yam, Agribusiness, Breeder, Plantlets.

INTRODUCTION

The productivity of yam in Nigeria is low when compared with the required optimal yield per hectare. (Balogun et al 2014). Seed yam producers are constrained with limited land area, poor soil fertility resulting from flooding and desertification, high labour cost, disease and pest infestation and unavailability of quality planting materials (Acheampong, et al 2020). The traditional approach has a slow propagation rate that occurs through vegetative propagation, thereby encouraging a build of so many diseases and pest infestation. Low quality seed yam containing pests and pathogens also result in a poor yield of ware yam tubers as well as yield loss of more than 80% (IITA, 2010). The expansion and increasing intensification of yam cultivation have raised the need for ensuring a sustainable availability of high-quality seed yam on a commercially viable basis in yam growing areas. However, high quality seed yam of improved genotypes is out of reach to most farmers. This has necessitated high demand for clean seed as up to 70% of production cost is spent on the purchase of seed yam (Ironkwe, 2005., Coyne, 2010 and Balogun et al 2014). Quality diseased free seed yam has been identified as one of the panaceas to enhanced yam productivity. To address these constraints, there is a need for developing an innovative yam propagation technique using other methods like the use of Temporary Immersion Bioreactor System (TIBS). TIBS is an advanced tissue culture (TC) technology, where plants are intermittently immersed in nutrient solution in contrast to conventional TC with continuous immersion. This novel technology was developed for high ratio propagation of high quality pre-basic and basic seed yam. The goal of increasing yam productivity for smallholder farmers in Nigeria can be achieved through innovative technologies among which is the use of Temporary Immersion Bioreactor System (TIBS). The use of new propagation systems for seed yam, which are quick, and result in clean planting material, thereby enhance the scaling up of formal seed yam production system. However, there is yet a report that put a cost on seed yam produced using this production process. The economic status of these seed yam production enterprise is yet to be established. This is necessary as it will encourage the incorporation of private sector into emerging formal seed system. This study is designed to empirically evaluate economics of seed yam plantlets produced from through TIBS for sustained seed yam production in Nigeria. This will be achieved through specifically to estimate the cost per plantlet from the production process, determine the profitability of yam plantlet produced from the enterprise and make recommendation to investors for better efficiency.

METHODOLOGY

The study used data collected from NRCRI tissue culture laboratory under the project of Yam Improvement for Income and Food Security in West Africa (YIIFSWA) sponsored by Bill and Melinda Gate Foundation. Data were collected on the cost factors for the production of yam plantlets and the selling price was established using 10% margin and the prevailing market price.

Analytical framework/model specification

Gross profit was used to determine the profitability of the enterprise. Thus
GP = TR-TVC -------------- (1)

Where:
GP = Gross Profit
TR = Total Revenue

TC = Total Cost of Production

Gross Margin (%) = GP/TR x 100-------- (2)

RESULT AND DISCUSSION

Capital Investment

The fixed cost was depreciated and calculated as was presented in Table 1. The items required to run a bioreactor include building which houses the production work space. The work space alone constituted about 33.95% to the annual fixed cost. Bioreactor vessel and screen house were also necessary as the constituted about 27.38% and 15.83% respectively of the total fixed cost. Other items include the shelves, Air conditioner and hardening tray altogether make up of about 10.29% of the annual fixed. The total annual fixed cost of N1,472,617 was incurred in running a bioreactor. Although is a capital-intensive venture but the cost could be spread along a time period.

Table 1: Depreciated cost of equipment associated with the production of seed yam plantlets in TIBS

Fixed Cost	Unit	Quantity	Unit Cost (N)	Total Cost (N)	Depreciated Cost
Production work space	Number	1	5,000,0000	5,000,000	500,000
shelves	Number	3	67600	202,800	40, 560
Electrical installation	Value		204,400	204,400	40,880
Bulbs	Number	3	1500	4500	2250
Air Conditioner	Number	1	138,000	138,000	46,000
Bioreactor Vessels	Number	8	252,000	2,016,000	403,200
Inverter	Number	1	750,000	750,000	75,000
Generator	Number	1	200,000	200,000	66,667
Screen house	Number	1	2,330,600	2,330,600	233,060
Hardening tray set	Number	5	39,000	195,000	65,000
TFC					1,472,617

Operational Cost

The results of the variable cost associated with the production of seed yam plantlets produced in temporary bioreactor system was presented in table 2. The items in the variable cost consist of consumables (reagents, Vivi packs, poly bag, labour and stock plantlets) The result shows that the total variable cost incurred in the production was N2, 523,409.78. The stock plantlets and the vivi pack were the highest contributors to the total variable cost amounting to 38.41% and 22.10% respectively. The total cost of production per annum was N3,996,026.78. The variable cost constituted about 63.15% and fixed cost 22. 79%.

Table 1: Variable Cost associated with the production of Breeders Seed yam in Temporary Immersion Bioreactor System (TIBS)

Input Cost (variable cost)		**Total of (A +B+C)**	**Kpamyo (A)**	**Asiedu (B)**	**Swaswa (C)**	**Amount (N)**
Stock plantlets @ 580 per plantlet	**No**	1671	919	369	383	**969,180**
Lab Reagents	**Unit**	**Quantity/l**	**Amt/l (N)**	**Amt / plantlet**	**Quantity used**	**Amt used (N)**

MS basal Powder 100 liters mixture @ #38,000/25l =152,000	g/l	4.43g/l	1,520.00	15.20	73.50l =73,500ml	111,720
Sucrose 2,500g @ #8000/500g = #40,000	g/l	30g/l	480.00	4.80	2205g	35,280
Myo –inositol 100g @ #68,500	g/l	0.1g/l	68.00	0.68	7.35g	5,034.75
Kinetin- 1g @ #45,000	g/l	0.05mg/l	2.25	0.0225	367.5mg= 0.3675g	16,537.5
Activated charcoal- 500g @ # 10,000	g	1g/l	20.00	0.20	73.50g	1,470
Lcystein – 100g @#76,000	g	0.02g/l	15.20	0.152	1.47g	1,117.2
Agar- 500g @ #38,000	g	7g/l	532.00	5.32	161g	12,236
Plant Preservative mixture 500ml @ #50,000/100ml= #250,000	ml	2ml/l	1,000.00	10.00	147ml	73,500
Sub Total						**256,895.45**
Consumables						
Screen House						
vivipack– 48 holes@#4,000	No	4000	83.33	139.395		557,583
Firewood @ #300 *20 drums =#6,000	bundle		1.5			6,000
Polybags	bundle	40	1000			40,000
Labor Soil Sterilization and bagging	No	250	2.5	20		10,000
TIBS		2734.50	27.345			200,001.33
Subtotal						**813,584.33**
Labour	**unit**		**unit cost**	**Value**		**Total Amount (Ngn)**
3 Laboratory assistant (monthly salary-N15000, spends 50% his time	man-days	150	300			135,000

daily on bioreactor activities						
Research asst. (monthly spends an average of 1 hour daily on supervision)	man-days	37.5	500			18,750
Subtotal						**153,750**
Maintenance						
Repairs	monthly	12	2,500			30,000
Diesel	liters	1,875	160			300,000
Subtotal						**330,000**
TVC						**2,523,409.78**
TFC						**1,472,617**
TC						**3,996,026.78**
Contingency 10% TC						**399,602.68**
Grand Total						**4,395,629.46**
Cost per plantlet						**201.66**

Revenue Estimation

Plantlets and micro tubers can be produced in Bioreactors. Plantlets could be due for harvesting between 8-10 weeks from the bioreactor vessel and further hardened in vivipack for at least two weeks. The result for the revenue estimate and gross margin analysis is presented in Table 3. The result shows that about 21,797 plantlets were produced within the period under review. An estimated price per plantlet was N262 (break-even price plus 30% mark-up). The gross profit for the period under review is N5,710,814 while the net profit is 1,315,184.54. the benefit cost ratio was reported to be 1.3, which implies positive returns to investment. The result shows that production of diseases free seed yam using Temporal immersion bioreactor is profitable.

Table 3: Gross margin Analysis

Table 4: Gross margin Analysis	
Revenue (1)	5,710,814
Variable cost (2)	2,523,409.78
Fixed cost (3)	1,472,617
Total cost (4)	4,395,629.46
Gross profit (1-2)	3,187,404.22
Gross margin	55.81%
Net profit (1-4)	1,315,184.54
Net margin	23.03%
Benefit Cost Ratio (1/4)	1.30:1

CONCLUSION

The study revealed that the production of yam plantlets in temporary immersion bioreactor should be considered a profitable business as it returns N1.30 in every N1 spent. This hope to increase in the long run as it is presently not running full capacity. It was therefore recommended that the scale of production should be increased in other to reduce cost of production.

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Assessment of the profitability and marketing efficiency of yam (*Dioscorea spp*) production within the last three planting seasons in Ebonyi State, Nigeria

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ABSTRACT

This study assessed the profitability and marketing efficiency of yam production among yam farmers within the last three planting seasons in Ebonyi State, Nigeria. Rapid rural appraisal (RRA) involving multistage purposive and stratified sampling technique was adopted for farmers' selection based on sampling frame of contact farmers of the Agricultural Development Programme (ADP) in Ebonyi State, to select a total of 216 yam producers and marketers of the study area. The result of multiple regression on the effect of socio-economic characteristic of the farmers had a coefficient determination (R^2) of 78.9% and four variables out of ten had a positive coefficient and were significant at 1% and 5%. Good farming experience, good source of income, good prices of ware yam and marital status would encourage utilization of more land and production profitable as they increased revenue significantly. Budgetary and marketing efficiency determination and profitability in yam production revealed that the business is profitable with gross margin of ₦1,440,000, ₦1,512,000 and ₦1,764, 000 per tonne transacted and hectares cultivated and in three seasons, 2015, 2016 and 2017 respectively. The Benefit cost returns indicated that every 1 naira invested in each year returned ₦1.50, ₦2.53 and ₦2.59, respectively. Yam production was profitable in all the seasons but was constrained by high cost of planting material, high cost of labour, land fragmentation issue, lack of capital and dearth of storage facilities and machineries. Based on the findings, the policies recommended were proffered.

Key words: Assessment, profitability, marketing efficiency, production, three planting seasons

INTRODUCTION

Yam *Dioscorea species*) among other root and tuber crops is a tropical tuber crop that belongs to the genus *Dioscorea* and family *Dioscoreaceae* and it production is becoming a business venture globally as they are now the most widely cultivated both in Asia, America and have real economic significant in Africa (Norman *et al*., 2012). In West Africa, yam production has been extensively expanded cultivating four million hectare yearly with about 48 million tons amounting to 95% global food supply (IITA, 2013). Nigeria is the largest producer of valued edible yams, accounting for 70% to 76% of total world production, with 35.07 million meteric tones and largest consumers of yams (USDA, 2011; FAO, 2013).Yam production generally has increased but marketing efficiency is not yet actualize and in this, boosting production without boosting marketing system can lead to glut of yam in the market. This can depress prices and discourage smallholder farmers from investing in yam and other root and tuber crops such as cassava cultivation, cocoyam etc. (IFAD, 2013). In recent years, yam producers in general and especially smallholder farmers have faced considerable difficulties in cultivation and other agricultural practices. Among the challenges are high cost of seed yam (FDAE,2014), others include high cost of input materials, poor storage facilities, high cost of labour, high cost of mechanization, inadequate extension services/ technical advice, inadequate funds, inadequate supply of high yielding varieties, bad access farm roads, effects of weather and climate, production and price fluctuations, lack of price control, preservation and storage problems, value addition among others (FMANR, 2006; ICA,2010;Izekor and Olumese, 2010; IITA, 2013).

Yam is one of the most profitable crop but mostly lost in storage as the conventional barn storage system is the only available option. Similarly, FAO (2013) reported that on the volume of yam lost in metric tons in Nigeria, Ghana and Côte D'Ivoire between 1961 and 2009; Nigeria lost an annual average of 10% within the period under study. The country recorded the highest yam lost in 2006 with over 3.7 million metric tons.. However, its cultivation is very profitable despite high costs of production, yield lost and price fluctuations in the markets annually (Izekor and Olumese, 2010; IITA, 2013). An average profit per yam seed, per harvest and storage in Nigeria, was calculated at over US$13, 000 per hectare harvested (IITA, 2013). Households demand for yam consumption is very high in Sub-Saharan Africa. This made yam production and marketing a profitable business in economic terms as noted by Okeoghene *et al*., (2013) in Ika South LGA of Delta State, Nigeria.

The production sustainability as one of the most economically valued root crops in Ebonyi State, contributing to the dynamic value chains that generate income for local population while continuing to play a leading role of supporting food security and diversification as revealed by profitable cost analysis with improved agricultural programs done in Ebonyi State in 2016 to 2017, above all other factor is dependent on marketing activities (Aja and Igboji, 2017). The incessant rise in price of the planting material is attributable to high cost of production, high level of demand, use as food during scarcity period, yield losses as a result of recent flooding, dwindling farm size among others (Eyitayo *et al.*, 2010). It is imperative to address marketing issues as agricultural development has been constrained by marketing of commodities. It is on this note that needs arose to assess the profitability and market efficiency of yam production, as one of the major staple and cash crop of smallholder farmers in Ebonyi state and Nigeria in general. The broad objective of this study is to assess the profitability and marketing efficiency of yam production within the last three planting seasons in Ebonyi State. Specific objectives include identifying the socio-economic characteristics of yam producers of the study area, investigating marketing practices of the respondents, estimating the cost and returns associated with yam marketing at farm level per van of a hectare, estimating the marketing efficiency, as well as identify the constraints in yam production and marketing in the study area.

METHODOLOGY

The study was carried out in Ebonyi State, Nigeria. Ebonyi state comprises of three senatorial zones with 13 Local Government, namely, Ebonyi North (Ohaukwu, Ebonyi,Izzi and Abakaliki LGA), Ebonyi Central (Ezza South, Ezza North, Ishielu and Ikwo LGA) and Ebonyi South (Onicha,Ohaozara, Ivo, Afikpo south and Afikpo North LGA) senatorial zones. Population of the study area comprises all potential yam producers according to Agricultural Development Programme (ADP) in Ebonyi State, as identified as the major yam producing areas in the three senatorial zones of the State based on State Department of Agriculture annual production figures 2018-2019. In the first stage, 3 LGAs each were purposively selected from the 3 senatorial zones based on massive yam production in the area.

In the second stage, 2 autonomous communities were selected from each of the 3 LGAs, to give a total of 18 communities. The third stage involved cluster sampling of the yam farmers. From each community, 3 stratified villages were selected and 4 farmers stratified according to gender per village was randomly involved. In all, a total of 216 stratified and randomly selected respondents participated in the study. Data were collected using interview schedule to obtain relevant information from respondents and by using questionnaires structured in line with the specific objectives. These were administered in form of oral interview schedule in order to ensure that responses to the questions were correctly filled. Descriptive statistics such as frequency counts, tables and percentages were used to analyze socio-economic characteristics of the respondents, marketing practices and challenges facing respondents. Budgetary analysis was used to estimate cost and returns associated with the enterprise of the respondents. The marketing efficiency was calculated using its standard formula while multiple regression analysis was used to analyzed objective (i) and objective (iv) was analyzed using factor analysis.

RESULT AND DISCUSSION

The coefficients of age, educational level, cost of labour, and farm size were statistically significant and negative at 5% level of probability, while the coefficient of source of income, cost of ware yam at farm gate prices, marital status and farming experience were significant and positive at 5% and 1% levels of probability, respectively. This implied that the older the farmer, the lower the ability to make decision guiding farm business. In other words, old age doesn't transmit to high yam production rather it declines production. Years of schooling has negative coefficient of variation and was significant at 5%. This implies that the more years the respondent spent in the school the lower the revenue due to less attention to farming business. The higher the cost of labour, the lower the hectares under cultivation. This implies that an increase in the cost of labour hired will lessen the number of land to be cultivated and the total revenue generated. The source of income, cost of ware yam, marital status and farming experience were positively signed with revenue and so the aprior expectation was met. The higher the source of income, the higher the land under cultivation, and the larger the family, the higher the land under cultivation and consequent the farm net income. This is true because farming experience increases farmers' knowledge on how to handle production practices and business in making good profit in return. This result corroborated with findings of Okoye *et al*., (2009) but contradict the result of Eyitayo *et al.* (2010) who reported positive effects of higher educational level, farm size and amount of credit obtained by seed yam farmers on output.

Budgetary and marketing efficiency determination

Table II result revealed that total revenue per hectare differed in each year and variable cost comprised cost of buying seed yam, clearing, land preparation, planting and harvesting, fluctuation cost of ware yam (farm gate price) plus cost of marketing (transportation, labour i.e. loading and offloading yam tubers, e.t.c). The average marketing efficiency (M.E.) for the three years is 126.95% and the marketing efficiency ranges from 110.28% of 2015 to 114.34% and 159.22% for 2017 and 2018 respectively. M.E. > 100% implies that the respondent covered the cost of marketing and made a margin above the 100%, hence yam tuber production in 2019 performed associated functions efficiently in comparison to other years in the study area. However, there was yield decline in 2019 but increase in demand of ware tubers suppressed the high cost of planting materials. This result is in conformity with findings of Izekor and Olumese, (2010) and IITA (2013) both noted that yam cultivation is very profitable despite high costs of production and price fluctuations in the markets annually (Izekor and Olumese, 2010; IITA, 2013).

Benefit cost Ratio per year = total revenue divided by total cost 2017 = 2.1, 2018= 2.4, 2019 = 2.6. Appreciated BCR is 2.1:2.4:2.6. If the BCR< 1, the business is not profitable; If the BCR> 1, the business is profitable. The result indicates that the business is profitable. This is in agreement with the result of Okeoghene *et al*., (2013) who observed that yam is profitable business in economic terms in Ika South LGA of Delta State, Nigeria.

Profitability in yam production

The enterprise budgeting as well as cost and return shown in Table II was used in determining the profitability of yam production in the study area. The findings showed that the total revenue from yam production differed in each planting season. Costs and returns to yam production result indicated that the total revenue, gross margin, net farm income and profit realized per hectare of sold ware yam tubers by farmers within the three years were ₦1,440,000, ₦1,512,000 and ₦1,764, 000 representing production per hectare for 2017, 2018 and 2019 respectively. Return on investment (ROI) showed that the amount realized by farmer on every one naira spent on production fluctuated within the three years. This can depress farmers from production. This findings corroborated with IFAD (2013) who noted depress prices can discourage farmers from investing in yam cultivation. The ROI showed that every 1 naira invested in each year returned ₦1.50, ₦2.53 and ₦2.59 respectively. seed yam cost was the highest variable cost item estimated approximately to ₦880,000 and representing 46.9 percent of total production cost of ₦1,978,370. The yam producers within the three seasons realized gross margin, net farm income and net return on investment of ₦943,300; ₦870,880; ₦1,003, 500 and net farm income ₦863,300; ₦950,830 and ₦1,003,500 and approximately net return on investment 1.54 respectively. The net return on investment approximately estimated to value of 1.54, implied that the sum of ₦1.54 was returned as profit on every N1 invested in the enterprise, thus indicating that yam production in the area was profitable. These findings were consistent with IFAD (2013) who reported various levels of profitability and positive return on investment in seed yam production. The result also consonance with FDAE (2014) who noted seed yam cost is the highest variable cost in seed yam production.

Constraints to seed yam production

The production constraints faced by yam farmers range from high cost of seed yam to low yield caused by climate vagaries. As indicated in Table III, high cost of seed yam was the prime production constraint with mean value of 5.0 on a 5 point scale. Lack of modern farm machineries and technologies to produce planting materials in the agrarian rural communities was found to be the main reason for the high cost of planting material. This was closely followed by high cost of labour necessitated by shortage of labourers which was attributed to rural-urban drift of young and middle aged men in search of white collar jobs leaving yam production in the hand old farmers.

Table I. Regression results for socio-economic determinant of Profitability and Marketing Efficiency in yam production.

Variable symbols	Variable Name	Regression coefficients	Standard Error	T-value	Significant level
Y	Constant	98456.712	5897.113	78.345	0.000 * **
X_1	Age	-312.191	298.276	-2.132	0.009* *
X_2	Gender	134.871	17.543	0.988	0.153 ^{NS}
X_3	Education	-246.164	125.118	-0.862	0.001* **
X_4	Marital status	283.213	186.312	-0.111	0.034* *
X_5	Farming experience	277.140	784.314	0.353	0.000 ***
X_6	Source of income	17.181	388.872	-0.067	0.071**
X_7	Ware yam (farm gate price)	70.496	234.047	-0.301	0.004* *
X_8	Labour cost	-11.123	561.321	-0.239	0.021**
X_9	Cost of transport	289.738	1667.143	0.431	0.276 ^{NS}
X_{10}	Farm size per hectare	-3524.497	3216.214	2.219	0.003**
R^2	78.9%				
R^2 Adjusted	72.3%				
F-stat.	2.53				

Source: Field survey, 2017. D. W. Stat. 1.89. ** indicate significant at 5% and 1% respectively. NS= not statistically significant. Dependent variable Y= Revenue

Table II. Comparative profit and marketing efficiency estimate of yam production in Ebonyi State, Nigeria

Parameter	**2017 Amount (₦)**	**Perc. (%)**	**2018 Amount (₦)**	**Perc. (%)**	**2019 Amount (₦)**	**Perc. (%)**
Total Revenue	1,440,000		1,512,000		1,764,000	
Land hire	30,000	5.2	30,000	4.8	30,000	4.4
Machete and hoe	12,000	2.1	12,000	1.9	12,000	1.8
Wheel barrow	21,000	3.6	21,000	3.4	21,000	3.1
Spraying machine	17,000	2.9	17,000	2.7	17,000	2.5
Total fixed cost	**80,000**	**13.9**	**80,000**	**12.9**	**80,000**	11.8
Variable cost						
Clearing per ha	16,200	2.8	18,000	2.9	18,500	2.7
Seed yam 29 ton/ha	275,000	47.7	285,000	45.9	320,000	47.0
Planting per ha	19,000	3.3	22,700	3.7	23,200	3.4
Staking	100,000	14.7				
Weeding 3 times per season	59,000	10.2	84,000	13.5	102,800	15.1
Harvesting (3 vans/ha)	12,500	2.2	16,000	2.6	18,000	2.6
Transportation	115,000	19.9	116,000	18.7	118,000	17.3
Variation in yield (van/ha) estimate	3.0		2.8		2.1	
Market price fluctuation						
Cost of ware yam (1kg...5kg/T) least	400 480,000		450 540,000		700 840,000	

Cost per van (3 vans/ha),1200t/van						
Total variable cost (TVC)	**596,700**	**86.1**	**541,170**	**87.1**	**600,500**	88.2
Total cost=TC (TFC +TVC)	**676,700**	**100**	**621170**	**100**	**680,500**	100
Gross margin (M=TR – TVC)	**943,300**		**870,830**		**1,003,500**	
Net farm income (NFI)=TR – TC	**863,300**		**950,830**		**1,083,500**	
Net return in investment (NFI/TC)	**1.50**		**1.53**		**1.59**	

Source: Field survey 2017/2018. T- Tuber

Table III. Mean ranking for factors and constraints to yam production

Constraints	Mean	Rank
High cost of seed yam	5.0	1st
Lack of improved varieties	3.5	7th
Land fragmentation issue	4.0	4th
Lack of capital	3.8	5th
High cost of labour	4.5	2nd
Low source of income	2.9	10th
Price fluctuation	3.7	6th
Low yield caused by climate issue	2.4	13th
Lack of modern storage facilities	3.4	8th
High cost of machineries	3.2	9th
Poor feeder road	2.5	12th
High cost of agrochemicals and fertilizers	2.8	11th
Flood and erosional agents	3.5	7th
Pest and disease infestation	4.2	3rd

Source: Field survey 2017/2018

CONCLUSION AND RECOMMENDATIONS

The result indicated that yam production irrespective of the constraints militating against its smooth operation in Ebonyi State, proved a profitable enterprise given the positive values of gross margin, net production income and net return on investment. Yam production in the study area was gender biased in favour of males who were majorly of old age with age-long experience in farming business and with poor level of education. Socio-economic factors such as source of income, cost of ware yam, marital status and farming experience were found to be statistically significant and positively related to gross margin, net income return on investment and total revenue. Major factors found to be militating against increased and profitable production level were high cost of planting material (seed yam), high labour cost, pest and disease problem, land fragmentation, lack of capital and dearth of modern production and storage facilities. Marketing system was efficient in all production seasons despite the fluctuation in price of yam and its product.

It was recommended based on the findings that government policies should be focused on ways of assisting yam farmers with improved planting material, lease land freely to farmers as well as provide machineries for farm work, provide pesticides and insecticides to yam farmers, established board that would serve as middle men between farmers and government, access modern implements and technologies. The producers and marketers should also establish cooperative societies to help ease financial challenge of members and stabilize price of produce per season. This among others would help to ameliorate pressing challenges to yam production and marketing in the study area.

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Soil Fertility Management Practices and Productivity of Arable Crop Farmers in Benue State, Nigeria

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ABSTRACT

The study estimated the Total Factor Productivity (TFP) and its determinants among arable crop farmers in Benue State, Nigeria with a view to examining the effect of soil fertility management on their productivity. Data were collected from 175 farmers using three stage sampling technique. Data analyses were carried out using descriptive statistics, Total Factor Productivity and least square regression analysis. Prevalent soil fertility management practices were; application of inorganic fertilizer (18.9%), crop rotation (15.4%), mulching (14.9%), application of organic manure (13.7%), alley cropping (13.0%), bush fallowing (12.6%) and cover cropping (11.5%). Result indicates that 46.9% of the sampled household heads were productive, i.e. have their productivity value above average across all the soil fertility management categories. Determinants of TFP estimate reveals the following factors as having a significant contribution to productivity at different levels of significance in the study area; age (-1.469), education (0.417), farm size (0.046), alley cropping (.357), crop rotation (.380), application of inorganic fertilizer (.503), mulching (.560) and organic manure (.373). While age impacted negatively on productivity, all others impacted positively on productivity. The study concludes that soil fertility management practices are productivity enhancer. Promoting sustainable soil fertility management practices that are farm or farmer specific is recommended.
Keywords: Arable Crop Farmers, Determinants, Household Heads, Soil Fertility Management and Total Factor Productivity.

INTRODUCTION

Agriculture still remain the mainstay of Nigeria's economy as it accounts for 22.36 percent of National Gross Domestic Product (GDP) and providing livelihoods to approximately 70 percent of the country's active labour force (Bernard & Adenuga, 2017; National Bureau of Statistic [NBS], 2022). Agricultural sector grew at the rate of 4.1 percent in 2016 and it accounted for 75 percent of non-oil exports. To improve the sectorial performance, the Federal Ministry of Agriculture and Rural Development (FMARD) has approved Agriculture Promotion Policy (APP), building on the Agricultural Transformation Agenda (ATA) developed under the administration of President Goodluck Ebele Jonathan. The key themes of this policy are supporting productivity enhancements; crowding in private sector investment and FMARD's institutional realignment with a focus to improving the ease of transacting business in Nigeria's agricultural space (Oredipe, 2017).

Productivity is generally defined as the level of output in relation to levels of resources employed in a given period of time. It is the rates of flow of output when compared to rates of flow of resources such as land inputs used in production (Oyaide, 1994). Poor agricultural productivity and food insecurity are persistent features of many developing countries including Nigeria. Increases in food production in the recent past in Sub-Sahara Africa (SSA) are a result of more land being brought into production rather than higher output per unit area of land (World Fact Book, 2012). With the increasing population, cultivable land is becoming the limiting factor in meeting the growing food demand, implying that farm output growth needs to be achieved through higher productivity (World Bank, 2008).

Soil fertility is the intrinsic ability or capability of the soil to provide plant nutrients and water in adequate amount and when required, for good growth and development of the crops. Soil fertility decline (also described as soil productivity decline) is the deterioration of chemical, physical and biological soil properties and its subsequent reduction in providing the crops with adequate nutrients and water (Agboola, 2001). Good soil fertility management practice helps rejuvenates the soil after each cropping season and also keeps the soil in good shape to support another season, thus, the need for appropriate soil fertility management practices. Soil fertility management practices can be seen as management of the soil to increase the quality and durability of the soil to provide required plant nutrient and water in an attempt to maintain optimum crop productivity (Food and Agriculture Organisation, [FAO] 2001 & Oladipo, et al., 2017). With constant cultivation of the soil to meet the growing demand for food amidst changes in climate and decrease in the ability of the soil to provide the required nutrients for plant, it becomes imperative that appropriate soil management practices are explored to ensure sustainable agricultural production.

Based on this, the objectives of the present study are in three folds. First, to isolate the different soil fertility management practices prevalent among the arable crop farmers in the study area, second, to estimate the productivity of the farming household heads stemming from the different soil fertility management practice most frequently practiced and third, to isolate the determinants of total factor productivity in the study area.

METHODOLOGY

The Study Area

The study was carried out in Benue State, Nigeria. The state which is one of the states that constitute the north-central zone of the country is made up of twenty-three (23) local government areas and shares boundaries with Nassarawa to the north, Taraba to the east, Cross River to the south, Enugun, Ebonyi and Cameroon to the south east, Kogi to the west. The state occupies a land mass of 33,955 square kilometers with an estimated population of 4,253,641 (National Population Commission, [NPC] 2006). The state experiences two (2) distinct seasons; wet and dry with an annual rainfall of between 1250-1750mm while annual temperature ranges between 32-38^{0}C. Inhabitants of the state are predominantly farmers and they cultivate such food crops as yam, rice, cassava, soya beans, groundnut, sweet potatoes, millet and guinea corn while such tree/cash crops like mango, citrus/oranges, pawpaw and pineapple could also be found. Major ethnic groups and tribes in the state are are Tiv and Idoma: others are Igede, Etulo, Jukum, Hausa, Akweya and Nyifon.

Sampling Procedure

The study population was arable crop farmers living in the study area; the data used were collected from the 2020 production season. A three stage sampling technique was used in the study. The first stage was the random selection of four (4) local government areas from the state, the second stage was the random selection of fourteen (14) communities/ villages with probability proportion to the size of the local governments, while the last stage was the selection of farmers from the selected villages/communities based on sampling frame. A total of 200 copies of the questionnaire were administered with only 175 returned with useful information that was used for the analyses as shown in Table 1.

Table 1: Sampling Procedure for the Selection of Farmers.

State	LGAs	Communities	Number of questionnaire administered	Number of questionnaire retrieved
Benue	Buruku	Abwa, Biliji, Mbataase and Mbaya	68	57
	Oju	Obotu,, Oronu-Ainu, Okpoma Ainu, Oyinyi, Iyeche and Uchuo	64	59
	Otukpo	Otukpoicho and Okete	32	29
	Ushongo	Sati ikov and Bilaji Ikom	36 200	30 175

Source: Field Survey, 2021

Analytical Technique

This study employed a number of analytical tools based on the objectives of the study. The tools include descriptive statistics, total factor productivity and multiple regression. Descriptive Statistics was used to describe the soil fertility management practices using frequency and percentage. Total Factor Productivity Model as employed by Adepoju and Salman (2013) was used to estimate the productivity value of the farming household heads based on the soil fertility management practice most frequently used. Total Factor Productivity (TFP) is a method of calculating agricultural productivity by comparing an index of agricultural inputs to an index of outputs (Jean-Paul, 2009). Total factor productivity is therefore measured as the inverse of unit cost following Key and Mcbride (2003). This is the ratio of outputs in naira value to the total variable cost (TVC) of production. TFP measures that use physical quantities as output measures rather than revenue actually exhibit even more variation than do revenue-based measures as documented in Foster *et al*., (2008). Hsieh *et al*., (2009) also find greater productivity dispersion in the TFP measures that use quantity proxies to measure output.

$$TFP = \frac{Y}{TVC} \quad \ldots\ldots 1$$

Where Y = Output in Naira value in line with Mwuese and Okorji, (2014).

TVC = Total Variable Cost

TFP = $\frac{Y}{\sum P_i X_i}$ i= 1, 2, …………..n……………………………………………………………………2

Where Y = quantity of output in Naira and P_i = unit price of ith variable input and X_i = quantity of ith variable input

The inputs used in line with Fakayode *et al*., (2008) are: cost of labour, cost of planting materials, Cost of inorganic fertilizer, Cost of herbicide and Cost of pesticide. Following Akintayo and Rahji, (2011) to examine the effect of some socio-economic variables as well as soil fertility management practices on the Total Factor Productivity (TFP), the TFP estimate was subjected to ordinary least square regression to obtain the coefficient of multiple determinations (R^2), F- Statistics, standard error and their values. The ordinary least square regression model is a best linear unbiased estimator whose estimate possesses the desirable properties of unbiasedness, efficiency and consistency.

Model Specification

$Q^* = f(X_1, X_2, X_3, X_4, X_5 \ldots\ldots X_{14}, \mu)$ ……………………………………………………………………………3

Where

Q* = TFP estimate

The Cobb-Douglas production function is specified as:

$Q_i = A \ \pi_i \ Z_i^{bi}$; $i = 1, 2, \ldots 14$ 4

The expanded form is:

$Q_i = A\, Z_1^{b1} Z_2^{b2} Z_3^{b3} Z_4^{b4} Z_5^{b5} \ldots\ldots Z_{14}^{b14} e^{ui}$ 5

Following Gujarati (2004), the empirical model to be used for this study can be cast in double-log form as follows:

$\ln Q_i = \ln A + b_1 \ln x_1 + b_2 \ln x_2 + b_3 \ln x_3 + b_4 \ln x_4 + b_5 \ln x_5 \ldots\ldots\ldots b_{14} \ln x_{14} + u$ 6

Based on the view of Hussain and Perera, (2004) and as adopted by Akintayo and Rahji, (2011), Adepoju and Salman, (2013) the following factors were hypothesized as the determinants of TFP of arable crop farmers in the study area.

x_1 = Age of household heads (years), x_2 Number of years of formal education, x_3 = Household size (number), x_4 = Farming Experience (years) , x_5 = Access to credit(Dummy Variable; Yes = 1 otherwise = 0), x_6 = Farm Size (ha), x_7 = Extension contact (Dummy Variable; Yes = 1 otherwise = 0), Vector of index of soil fertility management practices (Dummy Variable; Yes = 1 otherwise = 0), x_8 = Alley cropping, x_9 = Bush fallowing, x_{10} = Cover cropping, x_{11} = Crop rotation, x_{12} = Application of inorganic fertilizer, x_{13} = Mulching, x_{14} = Application of organic manure

μ = error term which is assumed to be normally distributed and with mean zero and constant variance

RESULTS AND DISCUSSION

Households Soil Fertility Management Practices in the Study Area

Table 2: Households Soil Fertility Management Practices.

Soil Fertility Management Practices	Frequency	%
Organic Manure	24	13.7
Bush Fallowing	22	12.6
Crop Rotation	27	15.4
Inorganic Fertilizer	33	18.9
Alley Cropping	23	13.0
Cover Cropping	20	11.5
Mulching	26	14.9
Total	175	100.00

Source: Field Survey, 2021

Productivity Estimate in the Study Area

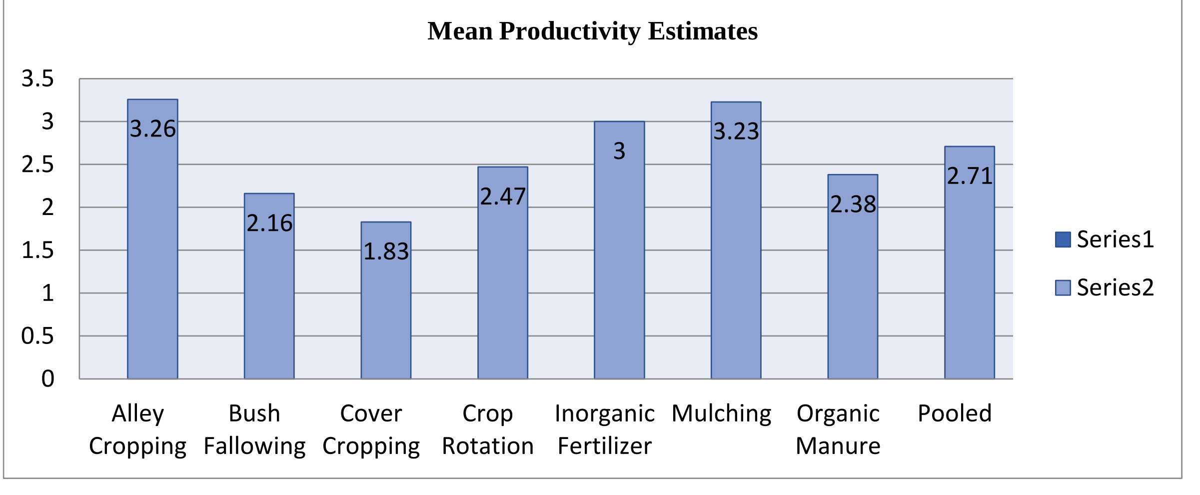

Figure 1: Bar Chart Showing the Mean Productivity Estimates Across the Different Soil Fertility Management Practices in the Study Area
Source: Field Survey, 2021

Factors Affecting Total Factor Productivity (TFP)

As shown in Table 3, the coefficient of determination (R^2) for food crop farmers (0.758) indicates the presence of a high degree of association between productivity (dependent variable) and all independent variables. This implies that 75.8% of the variation in the farmers' productivity is explained by the variations in the independent variables. The F-statistics of the farmers (F-test= 581.71, P<0.001) was found to be highly significant, implying that the independent variables were collectively important in explaining the variation in the dependent one.

Of the fourteen explanatory variables specified, eight were statistically significant. These were age, education, farm size, alley cropping, crop rotation, inorganic fertilizer application, mulching and organic manure application. The negative coefficient (p<0.01) of age suggests that farmers were less productive as they age, older farmers are not physically able to produce as much as younger household heads because productivity is countered by declining physical strength and perhaps by negative attitudes toward innovation. The negative coefficient, which implies that a unit increase in farmers' age decrease productivity by 1.46, agrees with the findings of Ahmed and Elrasheed (2016).

Table 3: Factors Affecting Productivity of Food Crop Farming Household Heads in Benue State

Variables	Coefficients	Standard error	T	P>|t|
Age	-1.469	.200	-7.33 ***	0.000
Education	.417	.149	2.80***	0.006
Household size	.006	.015	0.44	0.658
Farming experience	.006	.014	0.46	0.648
Access to credit	.003	.017	0.23	0.820
Farm size	.046	.073	3.35***	0.001
Access to extension	.034	.104	0.33	0.742
Alley cropping	.357	.199	1.79*	0.076
Bush fallowing	.044	.198	0.22	0.824
Cover cropping				
Crop rotation	.380	.193	1.97**	0.051
Inorganic fertilizer	.503	.213	2.36**	0.020
Mulching	.560	.189	2.96***	0.004
Organic manure	.373	.195	1.91*	0.000
Constant	1.055	.937	1.13	0.262
R^2	0.758			
R^{-2}	0.718			
Prob>F	0.0000			
F(13 147)	581.71			
N	161			

*** 1% significance level; ** 5% significance level; * 10% significance level
Source: Field Survey, 2021

The coefficient of years of education was positive and significant at 1% implying the significant contribution of the variable to productivity. This implies that a unit increase in years of education will tend to increase productivity by 0.417 unit. This is in conformity with the findings by Shittu et al. (2015) who stated that education increases farmers' productivity. The coefficient of farm size was positive and significant at 10% level and implies that a unit increase in farm size will tend to increase productivity by .034. This is likely to be so as farmers with large farms tend to enjoy economies of scale in the purchase of their inputs and sales of their output, thereby reducing the unit cost. The result conforms to the findings by Wawire at al. (2021).

Though not significant, the positive coefficient in respect of household size, farming experience, access to credit and access to extension contact implies that a unit increase in these variables tends to increase productivity by 0.006, 0.006, 0.003 and 0.0034, respectively. In addition, all the soil fertility management practices were positively related to TFP, implying that increased use of any of the management practices led to increased productivity. Although bush fallowing was not significant, alley cropping, crop rotation, inorganic fertilizer application, mulching and organic manure application were significant. The positive and significant value of organic manure is in line with Nuno and Baker (2021).

CONCLUSION AND RECOMMENDATIONS

The result of Total Factor Productivity estimate indicates that arable crop farmers practicing alley farming were the most productive while those practicing cover cropping were least productive. Practicing alley cropping, crop rotation, mulching and application of organic and inorganic fertilizer enhanced arable crop farmers' productivity in Benue State, Nigeria.

- Since age is negatively related to productivity, it is therefore recommended that youth empowerment program in the area should accord priority attention to agriculture so as to further encourage relatively young farmers into arable crop production.
- Education is productivity and soil fertility management enhancing variable since the level of formal education seemed to contribute to the total factor productivity of the farmers. This will not be unexpected as education has a way of helping farmers to reasonably commit their resources to any productive enterprise, resulting in increase in productivity. It is, therefore, recommended that basic education or adult literacy should be encouraged among farmers. There is need to constantly upgrade farmers' knowledge. Access to information on environmentally friendly and soil fertility management practices should be promoted through the provision of informal education for the farmers in the study area.
- Soil fertility management practices are productivity enhancer; the need to promote sustainable Soil fertility management practices that are farm or farmers specific is hereby recommended.

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Smallholder Arable Farmers' Perception Toward Climate Change And Its Coping Strategies In Selected Agro-Ecological Zones Of Ondo State

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ABSTRACT

The study determined the perception of smallholder arable crop farmers towards climate change and its coping strategies in Ondo State. A multistage random sampling procedure was used to select 160 respondents from two agro-ecological zones. Data were obtained with a well-structured questionnaire and analyzed using descriptive and inferential statistics (Chi square). Findings show that 37.5% were above 50years, 75.0% were males, 96.8% were married, 38.8% completed secondary education, 81.3% had less than 1.5 hectares of land, 35.0% had 6-10 years farming experience. Radio was the major source of information on climate change The study concluded that climate change is having adverse effect on the productive engagement of smallholder arable crop farmers and this could affect their livelihood activities. The study therefore recommended that smallholder arable crop farmers should stick to ethno-engineering practices to prevent and mitigate the effect of climate change.

Keywords: Small holder farmers, Arable crop farmers, Climate change, Coping strategies.

INTRODUCTION

The issue of climate change has become more threatening not only to the sustainable development of socio-economic and agricultural activities of any nation but to the totality of human existence (ResearchClue, (2019)). As further explained by USEPA (2009), the effect of climate change implies that the local climate variability which people have previously experienced and adapted to is changing and this change is observed in a relatively great speed. The threat that climate changes pose to agricultural production does not only cover the area of crop husbandry but also inclulivestock and in fact the total agricultural sector.

Effects of climate change have also metamorphosed into some impacts such as the decline in agricultural production, drought, migration, health problems, crisis among farmers and herdsmen, flooding, erosion, hunger and poverty among others and other numerous problems yet to manifest.

According to Apata (2012), evidence has shown that climate change is already affecting crop yields in many countries (Agbola, P. and Fayiga, 2016). This is particularly true in low-income countries, where climate is the primary determinant of agricultural productivity and adaptive capacities are low (Agbola, and Fayiga, 2016).

Vulnerability to climate change is however more prominent among smallholder farmers irrespective of their gender. Smallholder farmers are at disadvantage in a lot of ways including but not limited to limited access to farmland, inadequate fund to commercialize farming, low opportunities for training, lack of technical know-how and limited access to farm input among others. There is a dearth of information on perception of climate change in previous studies, however, the largest variability, in responses comes from the individual coping and adaptation strategies. It could be inferred at this juncture, that small holder arable crop farmers' perception of climate change could go a long way to affect performance and overall productivity of arable crop farmers. There is a need to therefore assess small holder's farmer's perception of climate change and its adaptation strategies in Nigeria, hence the reason for this study.

Objectives of the Study: the main objective of the study was to determine smallholder arable farmers' perception toward climate change and its coping strategies in selected agro-ecological zones of Ondo state. The specific objectives are to:

i. ascertain the socio economic characteristics of smallholder arable crop farmers in Ondo State Agro-ecological zone in Ondo State:

ii. determine the perception of small-holder arable crop farmers of climate change and coping strategies in the study area:

iii. identify the climate change coping strategies adopted by small-holder arable crop farmers in the study area: .

METHODOLOGY

The study was carried out in the Ondo State which is located in the Southwest of Nigeria. According to Ondo State Agricultural Development Programme (ONDADEP) delineation, Ondo State was divided into two major zones (the Northern part and the Southern part), it was further divided into four sub-zones and eighteen blocks or Local governments containing 162 cells or circles. Zone I (Northern part) covers 8 local Government. Zone II (Southern part) covers 10 Local Government. Two zones were purposively chosen from the 4 sub-zones considering the degree of their rurality. Ten percent of cells from each of the two zones were randomly selected from Owo and Okitipupa. However, ten percent of the registered farmers were randomly selected to give 90 and 70 farmers respectively from Owo and Okitipupa, Structured interview schedule was used to elicit needed information from the respondents. Descriptive statistics such as frequency counts, percentages, mean were used to present the results of the findings

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

Table 1 revealed that the mean age of respondents was 44 years which implies that the farmers were in their active ages and should be able to adopt both ethno-engineering adaptation techniques and series of micro- climate management practices aiming at reducing and or mitigating the destructive effects of climate change. Also, majority (80.6%) of the respondents were male, this implies that agricultural production in the study area is male dominated. Also, the Table further showed that most (97.5%) of the respondents were married. In the same vein, majority (86.2%) of the respondent had at least a secondary school education, implies that their level of education should have direct relationship in their ability to adopt varying adaptation and mitigation strategies against the manifestations of climate change in their farming activities. It also showed from the table that the mean household size was 7 people, it could be deduced that family labour will be available to assist in various adaptation and mitigation measures in response to the attendant effects of climate change (Odewumi,Awoyemi, Iwara and Ogundele, 2013). The Table depicted further that 80.0 percent of the farmers operated less than 1.5 hectare of land, while only few (2.5%) of the respondents had a farm size of above 2.91 hectares of land. With reference to the sources of information on climate change, the respondents got information from radio, co-farmers and agricultural extension agents (43.1%, 34.4% and 16.2%) respectively. This is in tandem with the submission of Oyelere, Sadiq, Olagoke and Adisa, (2020) that radio remains the major source of agricultural related information to farmers in Southwest Nigeria.

Table 1: Distribution of Respondents According to Socioeconomic Characteristics (N=160)

Socioeconomic Characteristics	F (%)	Mean Scores
Age		
21-30	14 (8.7)	
31-40	39 (24.4)	
41-50	71 (44.4)	44.0
51 and above	36 (22.5)	
Sex		
Male	129 (80.6)	
Female	31 (19.4)	
Marital Status		
Single	02 (1.2)	
Married	156 (97.5)	
Separated	02 (1.2)	
Educational Status		
No Formal	04 (2.5)	
Non-formal	12 (7.5)	
Primary	06 (3.7)	
Secondary	76 (47.5)	
Tertiary	62 (38.7)	
Household Size		
Less than 5 persons	31 (19.4)	
Between 6-10 persons	127 (79.4)	7.0
Between 11-15 persons	02 (1.2)	
Above 16 persons	-	
Farm Size (Hectare)		
Less than 1.5	128 (80.0)	
Between1.51 and 2.9	28 (17.5)	1.1 Hactares

2.91 and above	04 (2.5)	
Farming Experience (Years)		
Less than 5 years	10 (6.2)	
Between 6-10 years	39 (24.4)	9.5 years
Between 11-15 years	91 (56.9)	
Above 15 years	20 (12.5)	
Sources of information		
Television	55 (34.4	
Radio	69 (34.4)	
Co-farmers	26 (16.2)	
ADP Extension Agent	05 (3.1)	

Source: Field Survey, 2021

Perceived effect of climate change

Table 2 itemized the effects of climate change as perceived by the respondents on their farming activities in the study area. Majority (96.3%) of the respondents opined that climate change is responsible for flooding with its attendant effect on loss of farm produce, inability to go to their farms and possibly loss of lives when it persisted. The composite of flooding is soil degradation as submitted by 90.6 percent of the respondents. The removal of top soil is often caused by accelerated erosion and most spectacularly through flooding (Research Clue, 2019). From Table 2, most (90.6%) of the respondent affirmed that climate variability as an integument of climate change often necessitates adjusting planting dates to prevent colossal waste of resources in the Case of crop failure often precipitated by drought, pest and diseases. Also, 76.9 percent of the respondents traced the reduction in farm productivity to the debacle of climate change. This is in tandem with the opinion of Agbola and Fayiga, (2016) that extreme climate change manifestations such as fooling, extreme heat and drought often lead to soil degradation which results in low crop yield. Most (96.3%) of respondents perceived that excessive heat was a resultant effect of climate change.

Table 2: Distributions of Respondents According to the Perceived Effects of Climate Change (N=160)

Effects	Frequencies	Percentages
Flooding	102	63.7
Disruption of time of	145	90.6
planting	123	76.9
Reduction in farm yield	101	63.1
Changes in farming systems	145	90.6
Land degradation/ loss of		
soil nutrients	45	28.1
Deforestation	111	69.4
Fierce storms	154	96.3
High temperature		

Source: Field survey, 2021.

Coping and adaptation strategies

From Table 3, it showed that most (91.2%) of respondent often adjust crop production cycle in response to the probabilistic nature of the onset of rain, the length of drought and other variables associated with climate change that determine farm productivity. This is in line with the position of Nouri, et, al, (2017) that manipulating cropping calendar by changing sowing date is one of the ways to cope with the effect of climate change. Also, 65.6 percent of respondents affirmed that growing resistant varieties of crops to the vagaries of climate change effects, especially drought has proven to be an effective coping strategy. Further still, most (83.7%) of respondents opined that growing different crops has been one of the strategies they often adopt to mitigate the effects of climate change. This is in consonance with the assertion of Shuaibu, Akpoko and Umar, (2014) that one of the major strategies to adjust to the aftermath of induce shock occasioned by climate change is growing different crops. Reforestation and afforestation, better water management, adoption of soil moisture management such as mulching and application of organic manure, and application of integrated pest management, 13.7%,16.3%,27.5%3.8% respectively, were not considered despite their potency at ensuring environmental sustainability against climate change.

Table 4: Distribution of Respondents According to Coping and Adaptation Strategies (n=160)

Coping strategies	Frequencies	Percentages
Better water management	26	16.3
Adoption of soil moisture management strategies such as Mulching/organic matter incorporation.	44	27.5
	146	91.2
Changes to crop production cycles to align with seasonal fluctuation	62	38.7
Improved cultivation techniques and livestock management	22	13.7
Reforestation and afforestation	105	65.6
Investigating, identifying and growing drought tolerant crops	134	83.7
Growing different crops as a means of insurance	06	3.8
Application of integrated pest management practices		

Source: Field survey, 2021

CONCLUSION AND RECOMMENDATION

The study revealed that climate change had negatively impacted on farm productivity and livelihood activities of arable crop growers in the study area. It was obvious that it had also aggravated environmental degradation due to flooding, deforestation and fierce storms. However, arable crop growers in the study area were adopting some ethno-engineering practices to cope and adjust to the debacle of climate change, such as; growing varieties of crops, adjusting planting dates against the debacle of climate change. Based on the findings of the study, the study affirmed that arable crop growers in the study area were aware of the effects of climate change and as such adjusting to the effect of it. The study therefore recommended that smallholder arable crop farmers should stick to ethno-engineering practices to prevent and mitigate the effect of climate change. Agricultural information on climate change should be well packaged in a very simple language of the people on Radio to mitigate the effect of climate change. In order to migrate from small farm holding, it is further recommended that cooperative farming should be encouraged among farmers in the study area to guarantee food security and reduce the effect of climate change.

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Farm household food security status amidst farmer-herder conflict in southern Nigeria

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ABSTRACT

The study examined the food security status of farm households amidst farmer-herder conflict in Southern Nigeria. Specifically, it described the socioeconomic characteristics; examined the severity of the farmer-herder conflict and determined the household food security status. The study used primary data collected from the 3 geopolitical zones in southern Nigeria, with the use of structured questionnaire. The stratified sampling technique was used to select the respondents and data collected were analysed using descriptive statistics, binary logistic regression and Food Consumption Scores and results for conflict and non-conflict areas were compared using t-test. The result showed that the non-conflict area was 39.19% food secure while the conflict area was 8.23%. The t-test shows significant difference in the food security status of the two strata. The statistically significant difference in household food security status existing between conflict-affected and non-conflict respondents confirmed that production and situational variables are highly significant factors determining the severity of the conflict as well as the food security status. Since the result shows significant difference, all efforts should be made to resolve the conflict.

KEYWORDS: Household Food Security, Farmer-herder Conflict, Food Consumption Score

INTRODUCTION

Food, the most basic of all human survival needs, is one of the most important outputs of any agricultural system. Food is life, central to the discussion of human rights and social development and hence an instrument of national power (Jenkins and Scanlan, 2001; Ojo and Adebayo, 2012). Ensuring food security for all citizens in all societies is of immense importance that the 2030 United Nations adopted Zero Hunger as the second Sustainable Development Goal (SDG), articulated to end hunger, achieve food security, improved nutrition and promote sustainable agriculture. SDG 2 requires the attainment of the objectives through the households because the households are the basic units of every society. Food security is said to exist when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO 1996). FAO (2003) defined household food security as the application of the concept of food security at the family level, with individuals within households as the focus of concern.

Conflict occurs when two or more actors oppose each other in social interaction, reciprocally exerting social powers to attain scarce or incompatible goals and prevent the opponent from attaining them (Egbuta, 2018). A major violent conflict plaguing Nigeria in recent times is the farmer-herder conflict. It has been identified as one of the significant conflicts that causes food insecurity in the country as it involves two major actors in the food sector of the nation; the smallholder farmers and the herders. Apart from their contributions to the national GDP, the smallholder farmers are the engine room of food production in Nigeria, while the herders are the 80% custodians of cattle production in Nigeria, which is the main available source of animal protein in Nigeria (Ajala, 2006). Though this conflict is not a new occurrence, especially in the northern parts of the country, what is relatively new now is the increasing spread and magnitude of the conflict, particularly in the southern parts of the country.

Researchers have focused attention mainly on Northern Nigeria (Kazzah, 2018) and North Central Nigeria particularly Kogi and Benue States (Adisa & Adekunle, 2010). In Southern Nigeria, similar research has been conducted in Enugu state (Akerjiir, 2018), Cross River and Delta States (Ofem & Inyang, 2014) and in Oyo and Ogun States (Ayinde et al., 2020). However, there is a paucity of research on the conflict in other states in the southern part of Nigeria, its severity and its impact on household food security status in southern Nigeria as a whole.

The main objective of this study was therefore, to determine the farm household food security status amidst farmer-herder conflict in southern Nigeria. Specifically, the study described the socioeconomic characteristics of the respondents; identified the determinants of the severity of the farmer-herder conflicts and determined the household food security status of respondents in the conflict and non-conflict strata of the study area.

METHODOLOGY

Study area

The study area was southern Nigeria, which comprises of three geopolitical zones namely; South-East, South-West and South-South. Southern Nigeria is a conglomerate of 17 states. The area lies between the latitudes 4°32'N and 9°33'N of the equator and longitudes 3°25'E and 10°25'E of the Greenwich meridian (Ojemade et al., 2015). Southern Nigeria is a typical tropical climate, with the climatic zones running parallel to the coast, widening or narrowing as geographical features alter the steepness of the climatic gradient. The climatic zones are increasingly drier further inland from the coastal areas. The distribution of vegetation in southern Nigeria is dependent on the climate, therefore the area has varying vegetation zones comprising the rainforest zone in the south of River Niger, the mangrove forest of the coastal areas of Lagos, Calabar and Oron, and the guinea savannah of Oyo, Ondo, Enugu and the Anambra States. These vegetations offer an ample variety of fodders for grazing livestock, and as such attractive for pastoralists and equally supports the cultivation of variety of crops. The mean annual rainfall is from 2,000 to 2,500 millimetres (mm) (Ozor et al., 2010).

Sampling Technique

A multi-stage sampling procedure involving stratified and simple random sampling techniques, was adopted to select respondents from a state in each of the three geopolitical zones. Stage 1 was the purposive selection of a state that had witnessed the farmer-herder conflict. The selected states were Ebonyi State for the South-East, Edo State for South-South and Oyo State for the South-West. The second stage involved the purposive selection of 2 communities that have witnessed the conflict and two communities that have not witnessed the conflict from each of agricultural zones in the states. Stage 3 involved the determination of the sample frame from a reconnaissance study, from which the sample size was calculated using the Yamane formula, which gave the sample size of 627 respondents for the conflict stratum and 314 respondents for the non-conflict stratum, which were selected using the simple random sampling technique.

Analytical Techniques

The socioeconomic characteristics of the respondents were analysed using descriptive statistics. The determinants of the severity of the farmer-herder conflicts in the study area were identified using binary logistics model stated thus: $Y_i = \beta_0 + B_1 X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + \varepsilon_I$

Where Y_i = severity of the conflict measured in categorical variable (0 = not severe; 1 = severe) How was this categorized?

β_0 = intercept

X_1= socioeconomic factor expressed as mean of socioeconomic variables (obtained from a five-point Likert scale)

X_2 = situational factor expressed as mean of situational variables (obtained from a five-point Likert scale) What do you meam by situation variables?

X_3 = production factor expressed as mean of production variables (obtained from a five-point Likert scale)

X_4 = number of incidences of the farmer-herder conflict expressed as a continuous variable Number of incidence for what period? Wont this be the same for all the households in the same area?

X_5 = duration of the last incidence of farmer-herder conflict in days expressed as a continuous variable What is the unit of measurement? Duration (days? Hours? Week? Years?. Wont the duration be the same for all the households in the same area?

X_6= number of deaths per household resulting from the last incidence of farmer-herder conflict expressed as a continuous variable

X_7 = number of injured persons per household resulting from the last incidence of farmer-herder conflict expressed as a continuous variable

$\beta_1, \ldots, \beta_7$ = coefficient of the parameters $X_1 \ldots\ldots X_7$

εi = error term

The Food Consumption Score (FCS) was used to assess the household food security status of the respondents. The common local food eaten by households to ensure a nutritious diet, categorized into 8 food groups, were assigned different weights based on their nutrient contents in line with World Food Programme (2008).

RESULTS AND DISCUSSIONS

Socioeconomic characteristics of respondents

Table 1 showed the socioeconomic characteristics of the respondents. For the conflict stratum 86.9% were males, the mean age was 47.77 years and about 90% were married with a mean household size of 7 persons. The mean years of formal education was 8.89 years with 39.6% attaining between 7 to 12 years of formal education. The mean farm size was 3.48 hectares and an estimated annual income from their agricultural production was ₦ 688,305.71 while their estimated mean monthly food consumption was ₦ 44,280.99. In the non-conflict stratum, 83.4% of the respondents were with a mean age of 46.31 years with as many as 71.0% of the respondents aged from 40 to 59 years. About 88.9% of the respondents were married with a mean household size of 3 people. The average length of formal education is 9.74 years, the mean farm size was 2.32 hectares while their average estimated annual income was ₦ 388,865.1 and average monthly food expenditure was ₦ 46,350.88.

Table 1: Socioeconomic characteristics of farmer-herder stratum. The table looks too clumsy. Kindly remove the % and indicate below the table that all figures in ( ) are in %

Socioeconomic factors		Farmer-herder conflict stratum N=627	Non-conflict stratum N =314
Sex	Male	86.9%	83.4%
	Female	13.1%	16.6%
Age (years)	20-39 years	26.2%	18.5%
	40 - 59 years	60.1%)	71.0%
	≥ 60 years	13.7%	10.5%
	Mean	47.77	46.31
	Std. dev.	10.17	7.35
Marital status	Married	90.0%	88.9%
	Single	1.3%)	6.1%
	Widow/Widower	8.7%)	5.1%
Formal education (years)	None	25.1%	4.5%
	1-6 years	158(29.7%	31.5%)
	7-12	39.6%	45.9%
	>12	5.6%	18.2%)
	Mean	8.89	9.74
	Std. dev.	5.01	3.21
Household size (people)	1-2	8.9%	1.3%
	3-6	30.9%	62.1%
	>6	41.3%	36.6%
	Mean	7.0	6.00
	Std. dev.	2.0	1.70
Farm size (hectares)	<1	4.6%	6.4%
	1-3	48.3%	67.2%
	4-6	32.2%	18.2%
	7-9	5.6%	7.0%
	> 9	9.9%	1.3%
	Mean	3.48	2.32
	Std. dev.	2.95	1.13
Estimated annual income (N/Annum)	< 150,000	4.5%	3.5%
	150,000-300,000	16.7%	43.6%
	300,001-450,000	33.3%	20.7%
	450,001-600,000	24.7%	11.1%
	601,000-750,000	9.4%	19.1%
	>750,000	11.3%	1.9%
	Mean	688305.71	388865.1
	Std. dev.		140058.1
Monthly food expenditure (N)	≤15000	14.5%	2.9%
	15001-30000	34.9%	36.9%
	30001-45000	30.1%	16.2%
	45001-60000	14.2%	9.9%

	60001-75000	5.6%	33.1%
	>75000	1.3%	0.9%
	Mean	44797.92	46350.88
	Std. dev.	21813.75	7866.463

Source: Field Data (2022)

Determinants of the severity of the conflict

Table 2 showed the perception of the respondents in the conflict stratum on the severity of the conflict. About 70.3% of the respondents perceived the conflict as severe, which indicated that the conflict was severe in the study.

Table 2: Perception of the respondents on the severity of the conflict

Severity of conflict	Frequency	Percent
Not severe	186	29.7
Severe	441	70.3
Total	627	100.0

Source: Field Data (2022)

The output of the binary logistic regression presented in Table 3, showed that the Percentage Accuracy in Classification (PAC) of the model was 95.3%, showing that the model is relatively accurate. The output of the model further showed that the socioeconomic factors, situational factors, production factors, duration of the last incidence and death had significant effects on the severity of the conflict in the stratum. The variables that their odd ratios were greater than 1 were situational factors, production factors, number of incidences and injury, showing that the probability of the conflict being severe due to these factors is greater. The odd ratio of the model shows for any unit change in the situational factor, the log of odds of the conflict being severe increases 224 times; for any unit change in the production factor the log of odds of the conflict being severe increases 67 times; for any unit change in the number of incidences the log of odds of the conflict being severe increase 2 times, and for any unit change in the injury the log of odds of the conflict being severe increase 1.8 times. However, the number of incidents and injuries were not significant factors that determines the severity of the conflict.

Table 3: Determinants of the severity of the conflict

	B	S.E.	Sig.	Exp(B)
Socioeconomic factors	-8.614	1.944	.000***	.000
Situational factors	5.412	1.403	.000***	224.045
Production factors	4.205	1.304	.001***	67.013
Number of incidences	1.065	.841	.205	2.901
Duration of last incidence	-.082	.024	.001***	.921
Death	-1.993	1.108	.072*	.136
Injury	.637	.488	.192	1.890
Constant	-1.625	1.992	.415	.197

PAC= 95.3

*Significant at 10%; ***Significant at 1%

Source: Field Data (2022)

Household food security status

The result of the household food security of the respondents displayed in Table 4, showed that 39.60% of the respondents in the conflict stratum and 27.67% in the non-conflict stratum had poor scores in food security according to their level of consumption described on the Table 4. The scarcity of animal protein may be due to the driving away of the herders from the conflict communities making it impossible for the respondents to access animal protein. About 52.17% of the respondents in the conflict stratum and 33.14% in the non-conflict stratum were at the borderline of food security following their consumption level as shown in the Table 4. More of the respondents in the non-conflict stratum (39.19%), had an acceptable level of household food security as compared to 8.23% in the conflict stratum. This conforms to the opinion of Azad & Kaila (2018) that a major effect of the conflict included reduced agricultural production or price increases due to malfunctioning markets. This confirms that production and situational factors in Table 3 were very significant determinants of severity of the conflict which has affected their food consumption scores. The t-test shows a high statistical significance level at 5% as against the report of the research conducted by Azad & Kaila (2018) in the North East, North Central, and South-South zones; which reported that in North Central Nigeria, that showed that despites high food insecurity in the zones, there was no statistically significant level to conclude the differences observed. This may be because the severity of the conflict has heightened more than in 2018 when Azad & Kaila (2018) conducted their study.

Table 4: Household food security status using Food Consumption Score (FCS)

Household food security status		Farmer-herder conflict stratum (percent)	Non-conflict stratum (percent)	Description
Food insecure	Poor (≤ 28)	39.60	27.67	Consumption of staples 7 days, vegetables 5-6 days, sugar 3-4 days, oil/fat 1 day a week, while animal protein was totally absent
	Borderline (28.1 – 42)	52.17	33.14	Consumption of staples 7 days, vegetables 6-7 days, sugar 3- 4days, oil/fat 3 days, meat/fish/eggs/pulses1-2 days a week, while dairy products were totally absent
Food secure	Acceptable (42.1 - 105)	8.23	39.19	Had a greater number of days a week eating meat, fish, eggs, oil and complemented by other foods such as pulses, fruits and milk

Source: Field Survey Data, 2022

CONCLUSION AND RECOMMENDATIONS

This study concludes that the farmer-herder conflict has negatively affected the food security status of respondents. The study therefore recommends that:

1. there is a need for more concerted and deliberate efforts by stake holders and the government to find realistic and practical solutions to farmer-herder conflict because of the effect on production, socioeconomic and the number of lives lost from such incidences. Efforts by who?
2. The arable farmers should be encouraged to engage in backyard livestock production to augment their animal protein requirement.

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Global food losses and waste: towards more efficient, inclusive and resilient food systems

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ABSTRACT
Food losses and waste often translate into economic losses for farmers and others stakeholders within the food value chain, and higher prices for consumers, both of which affect food insecurity by making food less accessible for vulnerable groups. Food losses in low-income countries occur throughout food value chains, owing to managerial and technical limitations in harvesting, storage, transportation, processing, packaging and marketing. Food waste in middle and high-income countries is caused mainly by consumer behaviour and by policies and regulations that address other sectoral priorities. This review is focused on reduction of global food loses and waste and Making food systems more efficient, inclusive and resilient Reducing food losses and waste would increase the supply of available food and strengthen global food security.

INTRODUCTION
Food loses and waste comprises interconnected activities from the time of harvest through crop processing, marketing and food preparation, to the final decision by the consumer to eat or discard the food. Post-harvest food loss occurs within the farm-to-market period during harvesting, handling, storage, and distribution of food. These losses contribute to global hunger by decreasing both the supply of locally produced foods and purchasing power by reducing financial gains from crops.

Global food losses and waste
Globally, around one-third of all food produced is lost or wasted along the food chain, from production to consumption (HLPE, 2014). In a world where hundreds of millions of people go hungry, that is a stark indication of the inefficiency of current food systems. Food losses and waste often translate into economic losses for farmers and others stakeholders within the food value chain, and higher prices for consumers, both of which affect food insecurity by making food less accessible for vulnerable groups. Reducing food losses and waste would increase the supply of available food and strengthen global food security. Food losses and waste also hold back the transition to environmentally sustainable food systems (Alston, 2010). They represent

a considerable waste of land, water, energy and agricultural inputs, and cause the emission of millions of tonnes of greenhouse gases. Future efforts to address climate change will need to find ways to reduce food losses and waste. Because food production is responsible for a large share of GHG emissions, reducing food losses and waste contributes to climate change mitigation. At the same time, because climate change threatens food production in many food insecure areas, reducing food losses and waste can be an important part of climate change adaptation strategies (Bellú, 2016).
It has been observed that measuring food losses and waste is difficult, in part because food supply chains are long and involve many actors, including small farmers, transporters, processors, retailers and households. FAO (2012) defines food losses and waste as a 'decrease in quantity or quality of food', i.e. a reduction in the availability of food, a decline in its nutritional and/or economic value, and/ or deterioration in food safety. Food waste results from the 'discarding or alternative (non-food) use of safe and nutritious food for human consumption all along food supply chains'. Although the difference between food loss and food waste is not cut and dry, food loss is seen as accidentally occurring for reasons not under the direct control of the agents concerned, such as inadequate technology, lack of knowledge and skills, poor logistics and malfunctioning markets, while food waste is characterized by an element of intended or unintended behaviour, i.e. the removal of food fit for consumption by choice or negligence. Although food waste is often associated with final consumption, the deliberate discarding of food may occur at all stages of the supply chain. The distinction between food loss and food waste is important, because it underscores their different underlying causes. Policies and strategies need to take these into account when seeking solutions to the problem.

The causes of food losses and waste vary greatly by region

Accurate and time-wise estimates of losses and waste in the food system are unavailable. However, evidence to date indicates that, every year, about 670 million tonnes of food is lost or wasted in high-income countries, and 630 million tonnes in low- and middle-income countries – a total of 1.3 billion tonnes, or one-third of the edible part of food originally intended for human consumption (Alexandratos, and Bruinsma, 2012) Food losses and waste are caused by different factors at different levels:
• Micro-level causes resulting from the actions of agents at the same stage of the food supply chain (e.g. poor harvest scheduling and timing, poor harvest practices, careless handling of produce, lack of appropriate storage space, lack of transportation facilities, consumer behaviour).

• Meso-level causes related to a whole food supply chain, i.e. decisions or lack of decisions of agents in that particular chain (e.g. poor coordination, too long chains, failure to meet product standards, pesticide-contaminated processed products).

• Macro-level causes arising from the overall socio-economic environment, such as lack of infrastructure, inadequate legislative frameworks and price incentives and subsidies that promote excess production (HLPE, 2014).

In low-income countries, significant levels of food losses occur upstream, at harvest and during post-harvest handling, owing to poor infrastructure, low levels of technology, a limited knowledge base and lack of investment in production. Food losses also tend to be caused by managerial and technical constraints in harvesting, storage, transportation, processing, packaging and marketing. The greatest losses occur in small- and medium-scale agricultural and fisheries production and processing sectors. Uncertainty about weather and market conditions, and weak institutional frameworks, also contribute to losses. Each year in Africa, around 13 million tonnes of cereals, or more than 15 percent of total cereal production, are lost during post-harvest operations.5 In all regions, except South and Southeast Asia, food losses and waste account for more than 30 percent of food originally intended for human consumption. However, the extent of losses and waste along the food supply chain differs across regions (HLPE, 2014). In North America, Europe, Japan and China, around 15 percent of food is lost or wasted in the distribution and consumption stages. This percentage is lower in North Africa and Central Asia (11 percent) and much lower in Latin America, South and Southeast Asia and sub-Saharan Africa (5.9 to 7.8 percent). In contrast, North America, Europe, Japan and China lose or waste only around 15 percent of food in the harvest and post-harvest stages. In sub-Saharan Africa, where food losses and waste are particularly high at 36 percent, some 5.9 percent occurs in the retail and consumption stages, while more than 30 percent occurs in the harvest, post-harvest and processing stages.

Reducing food waste requires changing people's behaviour

In dealing with the problem of food waste, technological fixes do not offer lasting solutions. Responses must address the attitudes and actions of a range of stakeholders throughout the food supply chain. In high-income countries, food waste is caused mainly by consumer behaviour and economic decisions, and by policies and regulations related to other sectors. For example, agricultural subsidies may encourage the production of surplus food crops. This excess production helps contain prices but also causes less attention to be paid to food waste, both by value chain stakeholders and by consumers. Food waste is most often caused by retailers and consumers over-purchasing and then simply throwing away perfectly edible foodstuffs. In addition, food safety and quality standards may remove from the supply chain food that is still safe to eat. At the consumer level, inadequate planning of purchases and failure to use food before its expiry date also contribute to food waste. In addressing the behavioural causes of food waste, policy makers must recognize that food waste may be rational from an individual's perspective, resulting from the 'optimizing behaviour' of producers, processors, traders, and consumers. However, there are economic costs and negative externalities that individual economic agents may not consider, owing to imperfect markets and a lack of information.

From the point of view of society as a whole, food waste is considered undesirable because it generates net losses through its environmental impacts and associated socio-economic costs. Policies need to create conditions that enable the behaviour of different individual agents along the food supply chain to achieve a socially optimal level of food losses and waste. These policies include 'getting food prices right' by ensuring that the consumer assumes full responsibility for covering the environmental and social costs of producing – and eventually discarding – food. The recovery and redistribution of safe and nutritious food is another strategy option for reducing food waste.

Making food systems more efficient, inclusive and resilient

Food systems are characterized by the coexistence of modern and traditional supply channels. However, these systems are changing, as there is a growing reliance in many regions on global supply chains and large-scale distribution systems, such as supermarkets. Capital-intensive, vertically integrated supply chains both respond to the evolving demands for food and dietary preferences and shape the trajectory of their evolution. More efficient food systems also create new challenges and concerns: the high-calorie, but low-nutrient, content of many food items; the reduced access of small-scale producers and family farmers to viable markets; the high levels of food loss and waste; food safety problems; plant disease and animal health issues; and the higher energy intensity and heavier ecological footprint associated with the lengthening of

food chains. The implications of these challenges for future food security and nutrition will need to be viewed from the perspective of food systems at large, including the impacts on traditional food chains and the producers and consumers who rely on them.
Strengthened linkages between farms, markets and consumers can be an important source of income growth and job creation in both rural and urban areas.

CONCLUSION

Food losses in low-income countries occur throughout food value chains, owing to managerial and technical limitations in harvesting, storage, transportation, processing, packaging and marketing. Food waste in middle and high-income countries is caused mainly by consumer behaviour and by policies and regulations that address other sectoral priorities. For example, subsidies may encourage surplus food crop production, which reduces both prices and the attention that is paid to food losses and waste. Some food safety and quality standards may remove from the supply chain food that is still safe for human consumption. At the consumer level, inadequate planning of purchases and failure to use food before its expiry date also lead to waste. The challenge for many low- and middle-income countries will be to find dynamic pathways that connect local food systems to growing urban markets and to seize market opportunities. Cities account for the lion's share of demand for high-value foods, such as fruits, vegetables and dairy products. These are markets in which small-scale and family farmers can have an advantage because such products are labour-intensive. Food systems that link farmers to cities can have an enormous impact on rural poverty alleviation and agricultural development. Options include connecting small-scale producers and supermarket supply chains through contractual arrangements with mutually beneficial terms, and giving new impetus to the development of local food systems.

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Information sources and knowledge level of sweet potato production in Ebonyi State.

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ABSTRACT

Information is one of the most valuable resources for the development and progress of any enterprise. This study examined the sources of information and level of knowledge of sweet potato production by rural farmers in Ebonyi state. Primary data were collected from 400 small-scale sweet potato farmers using a multi-stage sampling procedure. The instrument used for data collection was interview schedule. Data collected were analysed using descriptive statistics. Findings reveal that fellow farmers with mean of (2.91) ranked 1st as the major source of information on sweet potato production in the study area while research institution with mean (1.87) ranked 6th as the least source of information on sweet potato production. For the knowledge level of the respondents on sweet potato production, some improved agronomic practices ranging from site selection, planting depth, sweet potato tillage practices, planting materials, fertilizer application, harvesting, storage and products forms were indicated by majority of the farmers that they have good knowledge of them as(55.5%) of the sweet potato farmers have high knowledge of sweet potato production. The result therefore call for policies aimed at enlightening farmers on the importance of formation of farmers groups since most trainings on new technologies, value addition, access to information on market opportunities and provision of loan packages can easily be disseminated through farmers group.

Keywords: Information sources, knowledge level, sweet potato,

INTRODUCTION

Sweet potato (Ipomoea batatas) is an important root crop that provides food to a large segment of the world population, especially in the tropics and subtropics where bulk of this crop is cultivated and consumed. Sweet potato is an important food crop in Nigeria that is valuable in the diet of rural poor in the tropics (Odebode, 2004). It is a low input crop and it is used as a vegetable, a desert, source of starch and eaten as a substitute for yam as a result of lower cost of production. The importance of the crop in national and household food security coupled with health and livelihoods of poor farming households in Nigeria cannot be over-emphasized.

In Nigeria, sweet potato production, marketing and utilization have expanded beyond the traditional areas of the central and river-rine zones to the humid and semi-arid regions in the last two and half decades (Tewe *et al*., 2003). Nigeria is one of the largest producer of sweet potato in sub-Saharan Africa with annual production estimated at4.03 million tons per year with farm size of about1.7mha and yield of 2.3t/ha (FAO, 2018). It can be grown three times a year, has a high yield potential, high nutritional value, resistance to production stress, environmentally friendly with diverse food forms among others (Ikwelle, Ezulike, & Eke-Okoro, 2001 and Kays,2004). The crop has moved up from the minor status to an enviable position of being the fourth most important root and tuber crops in Nigeria after cassava, yam and Cocoyam.

Sweet potato cultivation is still restricted to a few states and its production is mainly for local consumption (Ikerogu, 2003). The crop is often grown at a subsistence level, as a mono-crop or intercropped with other crops such as maize, yam, cassava and vegetable (Akoroda, 2009). Sweet potato is a drought tolerant crop with the potential to enhance food and nutrition security, especially for subsistence and small-scale farmers in Nigeria. For sweet potato, drought stress accounts for 25% total annual yield loss compared to more than 50% yield loss or complete failure in staple crops such as maize.

Despite this advantage, its importance as a food security crop is still underestimated and fails to attract sufficient attention from agricultural researchers (Motsa *et al.*, 2015). Sweet potato sector has lots of potentials for increased productivity in the country as the nation are blessed with rich and abundant sweet potato growing environments and numerous programmes, policies and improved varieties (Chukwu, 2013). This work is therefore designed to identify the sources of information and knowledge level of sweet potato production in Ebonyi State.

METHODOLOGY

Structured interview schedule was used as instrument for data collection. The study area was Ebonyi State with all the three Agricultural Zones; Ebonyi South, Ebonyi North and Ebonyi Central which followed a multi-stage sampling procedure. In the second stage, two local government areas (LGA) in each zones were purposively selected based on cropping intensity. Afikpo-South and Onicha LGAs were selected in Ebonyi South, Ohaukwu and Abakaliki LGAs for Ebonyi North and Ikwo and Ishielu LGAs for Ebonyi Central. In the third stage, two Council Wards were also purposively selected from each LGA, giving twelve Council Wards. Simple random sampling technique was used to select respondents who are sweet potato farmers in the study area. Consequently, thirty four (34) respondents each was systematically selected in four council wards giving a total of one hundred and thirty six respondents in Ebonyi central zone, because of its higher population. Thirty three (33) respondents were selected in eight council wards in Ebonyi-North and Ebonyi-South zones each, giving a total of two hundred and sixty four respondents in the zones. Thus, bringing total respondents administered with interview schedule to Four hundred. In analysing data generated for the study, descriptive statistics like percentages were used to describe the state of knowledge of sweet potato while three point likert rating was used to identify and rate the sources of information on sweet potato production in the study area.

RESULTS AND DISCUSSION

Table 1 revealed that fellow farmers with a mean of (2.91) ranked 1st as the major source of information on sweet potato production in the study area. This indicated that farmers in the study area have cordial relationship with one another; hence information regarding sweet potato production is well circulated among fellow farmers. Friends and neighbours had a mean of (2.80) and ranked as 2nd major source of information on sweet potato production. This is in line with the findings of (Omoare, 2014) who reported that majority 86.0% of the respondents always source their information on sweet potato production from their friends and neighbours. It also agrees with the findings of Mmasa *et al*. (2013) that sweet potato farmer's source information through their friends and fellow farmers. Similarly, respondents identified extension agents as 3rd source of information on sweet potato production. This implies that extension services have been an effective means for sweet potato farmers to source information from. This is quite beneficial for sweet potato production in the study area. Cooperative / farmers group with a mean of (2.15) ranked as 4th source of information on sweet potato production. Farmers group played a significant role in sourcing information on sweet potato production among its members. Information on improved sweet potato varieties and the recommended agronomic practices for optimum yield such as time of planting and harvesting, fertilizer and herbicide use, marketing and value addition of sweet potato are disseminated to their members. Radio/television with mean of (2.07) ranked as 5th source of information on sweet potato production but they are not the major source of information for sweet potato farmers in the study area because some of the farmers do not have television or radio to access information. Research institution with mean (1.87) ranked 6th is a source of information on sweet potato production but a minor one. Farmers do not usually access research institution for information on their farm practices.

The results in Table 2 indicated that majority (77.2%) of the respondents agreed that suitable site for sweet potato production should not be in waterlogged soil. About(82.5%) of the respondents indicated that soil depth of 20cm is satisfactory for sweet potato production while (91.6%) of the respondents indicated that sweet potato planted on ridges produce higher yields. This result is in conformity with the findings of (Omoare, 2014) which indicated that planting sweet potato on ridges gives room for easy farm operations and produces higher yields. Farmers' knowledge on sweet potato production was ascertained based on vines as the best planting material. About (98.1%) of the respondents are knowledgeable with vines as the best planting materials. Majority of sweet potato farmers agreed that some good agronomic/management practices of sweet potato production such as use of soil rich in organic matters for sweet potato production (85.8%), crop rotation to control sweet potato weevils(73.8%), application of fertilizer four weeks after planting (74.8%) and herbicide application as the best method of weed control in sweet potato farm(51.3%) enhances yield of sweet potato. Also, (89%) of the respondents agreed that sweet potato tubers matures when leaves stem/vines developed yellow colour and dies off.

In the same vein,(83.2%) of sweet potato farmers ascertained that bruising during harvesting and transportation should be avoided as this predisposes the tubers to pathogenic organism which will lower the shelf live and reduce the economic value of sweet potato.

Majority (64.6%) of the respondents indicated that they do not practice storage of sweet potato tubers after harvesting in pits with ashes, straw or grasses or did not have knowledge of this storage method for sweet potato. However,(81.6%) of the respondents indicated that piece meal harvesting of sweet potato is an indigenous practice on sweet potato farms that enable them to have food for longer period of time and to harvest and use as source of income in time of need. Furthermore, adding value to sweet potato through processing into diverse food forms and washing of tubers after harvesting enhances the marketability and acceptability of sweet potato to consumers as revealed by (85.6%) and (88.2%) of the respondents respectively. Result in table 2b revealed that (55.5%) of the sweet potato farmers have high knowledge of sweet potato production. This implies that farmers are not new in sweet potato production in the study area. Also (27.8%) and (16.7%) of the respondents had moderate and low knowledge of sweet potato production respectively.

Table 1: Farmers' sources of information on sweet potato production

Source of Information	Mean	Rank
Fellow farmers	2.91	1st
Friends and neighbours	2.80	2nd

Extension agents	2.47	3rd
Cooperative/ Farmers group	2.15	4th
Radio/Television	2.07	5th
Research Institution	1.87	6th

Source: Field Survey, 2019

Table 2: Distribution of respondents by their Knowledge level on sweet potato production practices.

S/N	Items	True	False
i	Suitable site for sweet potato cultivation should not be in a waterlogged soil	295(77.2)	87(22.8)
ii	Soil depth of 20cm is satisfactory for sweet potato	315(82.5)	67(17.5)
iii	Sweet potato requires minimum tillage practices to ensure adequate yield and better tuber formation	200(52.3)	182(47.6)
iv	Sweet potato planted on ridges produce higher yields	350(91.6)	32(8.37)
v	Sweet potato is a suitable intercrop and it obstructs erosion	335(87.7)	47(12.3)
vi	Yield in sweet potato declines drastically once intercrops suppress the sweet potato crops	290(76)	92(24)
vii	Vines are the best planting materials for sweet potato	375(98.1)	7(1.83)
viii	Soil for planting sweet potato should be rich in organic matter	328(85.8)	54(14.1)
ix	Crop rotation controls the spread of sweet potato weevil.	282(73.8)	100(26.1)
x	Fertilizer application should be done 4 weeks after sweet potato establishment on the field	286(74.8)	96(25.1)
xi	Spraying herbicide is the best weed control method for sweet potato	196(51.3)	186(48.7)
xii	Tubers are mature when leaves/stems/vines develop yellow colour or dries off	340(89)	42(10.9)
xiii	Bruising during harvesting and transportation should be avoided as this predisposes the tubers to pathogenic organisms	318(83.2)	64(16.7)
xiv	Storage of sweet potato tubers can be in pits with ashes, straw or dry grasses spread on them.	135(35.3)	247(64.6)
xv	Piece meal harvesting is an indigenous practices which may reduce weevil attack on sweet potato farms	312(81.6)	70(18.3)
xvi	Harvested tubers can keep long by processing it into diverse products forms such as sweet potato flour, sweet potato chips	327(85.6)	55(14.4)
xvii	Prior to marketing of sweet potato, the tubers must adequately be washed to look attractive to the consumers.	337(88.2)	45(11.7)
xviii	Decline in sweet potato production can be attributed to low knowledge of the farmers on sweet potato value addition	268(70.1)	114(29.8)

Source: Field Survey, 2019

Values in parenthesis are percentages

Table 2b:Categorization of farmers' knowledge level of sweet potato production(n=382)

Knowledge level	Scores	Frequency	Percentages
High Knowledge	30-36	212	55.5
Moderate Knowledge	23-29	106	27.8
Low Knowledge	18-22	64	16.7

Source: Field Survey, 2019

CONCLUSION

Farmers' sources of information had influence on the decision to accept or reject a technology or innovation. Knowledge level of sweet potato farmers in the study area were also determined using 18 items. It was discovered that fellow farmers ranked first on farmers sources of information on sweet potato production in the study area while research institution ranked 6th and last position on the farmers' sources of information on sweet potato production. For knowledge level of sweet potato, majority of the farmers reported having knowledge of good agronomic practices of sweet potato production ranging from site selection, planting depth, sweet potato tillage practices, planting materials, fertilizer application, harvesting, storage and product forms.

It is recommended that rural sweet potato farmers should join farmers group where information and trainings on new technologies and management practices, value addition, access to information on market opportunities are disseminated among members. Also, increase in extension outreach, provision of loan packages to help farmers expand/establish their sweet potato farm which serves as a means of their livelihood in the study area.

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Assessing the Utilization of Odourless Cassava Fufu Processing Technology among Households in Abia and Imo States, Nigeria

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ABSTRACT

The study assessed the utilization of odourless cassava fufu processing technology among households in Abia and Iimo States, Nigeria. A purposive and multistage random sampling procedure was used to select a sample of 180 respondents across the two states. Data were collected through well-structured questionnaire. Descriptive and inferential statistics were used to realized and test data. Respondents in the two states use similar methods in processing odourless cassava fufu and high level of utilization of odourless cassava fufu was recorded in the two states. The tobit result shows that households' socio-economic characteristics have a lot of bearing on their ability to partake and utilize the technology. The study recommended the use of more channels of communication in technology dissemination in other to get the target goal desired by the developers of the technology and there is need to revive the extension services programme for appropriate and effective technology dissemination and follow up.

Keywords: Assessing, Utilization, Odourless Cassava, Fufu

INTRODUCTION

Cassava Fufu is the second major product next to gari in importance and consumed by households in South-eastern Nigeria (Saleh *et al*., 2016). It is a fermented wet paste made from cassava roots. Traditionally, it is produced in the wet form with moisture content of 40 -50 percent and with characteristic offensive odour (NRCRI, 2012). In order to increase its shelf life, quality and quantities supplied, odourless cassava fufu processing technology was developed by the National Root Crops Research Institute, Umudike some decades ago. Odourless cassava fufu is a fermented carbohydrate food produced from cassava root, unlike the traditional fufu which is normally in wet form, and highly perishable. The fufu is presented in dried form, is odourless, inelastic and slightly sour having a low particle size and zero cyanide content (Ekweanya, 2020). Odourless Cassava fufu processing involves a combination of activities which are performed in stages. The National Root Crops Research Institute

(NRCRI), Umudike having promoted value addition and processing technology for odourless cassava fufu years back, it is expected that these technologies would have been in use in different locations for consumption, income generation and creation of employment (Nwakor *et al*., 2014). This study, therefore, sought to provide information on the level of utilization of odourless cassava fufu processing technology among households in Abia and Imo states, Nigeria, and to specifically identify the different type of methods of processing odourless cassava fufu; examine the level of utilization of odourless cassava fufu based on preferred improved cassava varieties; and identify challenging factors to utilization of odourless cassava fufu in Abia and Imo states

METHODOLOGY

The study was carried out in Abia and Imo States located in south-east Nigeria. A multi-stage sampling technique was used to elicit data for the study. In the first stage, two LGAs were purposively selected from each the state (Abia State- Umuahia North and Ukwa west; Imo State-Owerri west and Nkwerre) making it four LGAs. The reason for purposive selection is because value-added innovations of cassava have been massively introduced in those states through suitable training. In the second and third stages, three communities and three villages were randomly selected from each of the LGAs and communities, making it twelve communities and thirty-two villages. In the fourth and last stage five respondents were purposively selected from each village to give a total of one hundred and eighty respondents, ninety respondents from each state. Well-structured questionnaire was used to interview the respondents, in all 180 respondents made up the sample size for the survey. Data collected were analysed by means of descriptive statistics, mean count and tobit regression model.

RESULTS AND DISCUSSION

The result in Table 1 revealed that the respondents were utilizing almost all the methods involved in the processing of odourless cassava fufu technology, 100%of the respondents agreed on peeling, washing, fermentation, grating the cassava mash and dewatering in Abia and Imo states. Also, majority of them utilized other methods accordingly. This implies that the respondents in the two states use similar methods in processing odourless cassava fufu. This findings is in accordance with the report of Ekweanya (2018).

Table 1: Different types of Processing Methods Utilized in Processing Odourless Cassava Fufu by the Respondents

Odourless Cassava Fufu processing methods	Abia Freq	%	Imo Freq	%	Pooled
Peeling cassava roots	90	100	90	100	100
Washing cassava peeled roots	90	100	90	100	100
Soak in water for two days fermentation	90	100	90	100	100
Remove from water and grate into cassava mash	90	100	90	100	100
Put the grated mash into a container, cover and leave for 24 hours	71	78.9	84	93.3	86.1
Dewater the mash by pressing inside a clean bag	90	100	90	100	100
Break the pressed caked mash into granules	69	76.7	73	81.1	78.9

Spread thinly to dry on a clean surface preferably on a raised platform	55	61.1	68	75.6	68.4
When dry, mill into fine powder and sift	60	66.7	80	88.9	77.8
Package in an air tight container or food-grade polythene bag	42	46.7	69	76.7	61.7

Source: field survey, 2021 multiple responses recorded

Level of Utilization of Odourless Cassava Fufu based on Improved Cassava Preferred

The level of utilization of odourless cassava fufu with improved cassava varieties were examined (Table 2) and it shows that the mean utilization score of TME 419, TMS 89/0505, TMS 89/0851, other varieties which are higher than the decision mean cut off of 2.5 is an indication that users prefer using the mentioned varieties to process odourless cassava fufu in the study area. Furthermore, the grand mean score for Abia (2.8) and Imo (2.9) is an indication that the level of utilization of odourless cassava fufu is higher among households in Imo than their counterparts in Abia. Low utilization of NR 8082, pro vitamin A cassava and TMS 89/0851 calls for serious attention and upgrading.

Table 2: Level of Utilization of Odourless Cassava Fufu based on Improved Cassava Varieties Preferred

				Abia							Imo			
Varieties	**N**	**R**	**MT**	**A**	**T**	**M**	**Re**	**N**	**R**	**MT**	**A**	**T**	**M**	**RE**
NR 8082	17 (17)	25 (50)	37 (111)	11 (44)	222	2.4	Low	15 (15)	21 (42)	29 (87)	25 (100)	214	2.4	Low
TME 419	3 (3)	6 (12)	20 (60)	61 (244)	319	3.5	Very High	1 (1)	3 (6)	8 (24)	78 (312)	343	3.8	Very High
Pro Vitamin A Cassava	21 (21)	27 (54)	29 (87)	13 (54)	216	2.4	Low	16 (16)	33 (66)	21 (63)	20 (80)	222	2.4	low
TMS 89/0851	23 (23)	16 (32)	20 (60)	31 (124)	221	2.4	Low	20 (20)	21 (42)	25 (75)	24 (96)	233	2.6	High
TMS 89/0505	13 (13)	19 (38)	17 (51)	41 (164)	266	2.9	High	9 (9)	13 (26)	15 (45)	53 (212)	292	3.2	Very High
Other varieties	12 (12)	12 (24)	23 (39)	43 (172)	247	2.7	High	23 (23)	11 (22)	27 (81)	29 (116)	236	2.6	High
Grand mean						**2.8**	**High**						**2.9**	**High**

Source: field survey, 2021 *(N=Never, R=Rarely, MT=Most Times, A=Always, T=Total, M=Mean) Average mean=2.5, mean less than 2.5 is not well utilize and any mean greater than 2.5 is well utilize.*

Challenging Factors to Utilization of odourless cassava fufu in Abia and Imo states

The majority posited that poor extension contact (73.9%) high cost of technology, (57.8%), undesirable traits (57.2%), unavailability of improved cassava stems for planting (53.4%), some of the improved cassava used for the cassava odourless fufu not being palatable (53.4%) greatly affected utilization of odourless cassava fufu technology in the study area.

Table 3: Challenging Factors to Utilization of odourless cassava fufu in Abia and Imo states

	Abia State		**Imo State**		
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Pooled**
High cost of technologies	81	90	77	85.6	57.8
Poor extension contact	72	80	61	67.8	73.9

Undesirable Traits	56	62.2	47	52.2	57.2
Unavailability of improved stems for planting	51	56.7	45	50	53.4

Source: field survey, 2021 *multiple responses recorded

Determinants of utilization of odourless cassava fufu in Abia and Imo states

The relationship between households' utilization of odourless cassava fufu and socio-economic characteristics in the study area was analyzed using tobit regression model. The R^2 value (0.457) for Abia state which implies that about 46% of the variation and R^2 value (0.665) for Imo state which implies that about 67% of the variation in the utilization of odourless cassava fufu was explained by independent variables and Chi^2 was highly significant at 1% level of probability respectively indicating goodness of fit. For Abia state, the results in table 4 depict that sex was negative and significant at 5% level of probability, implying that more women utilize odourless cassava than men. Household size, level of education, experience and sources of information were positive and significant at 10% and 1% level of probability respectively. This implied that increased number of households, possession of formal education, advanced in experience of processing odourless cassava and sources of information increase the utilization of odourless cassava fufu. Similarly, the result shows that for Imo state, sex was negative and significant at 10% level of probability, education, experience, sources of information and cassava output were positive and significant at 10%, 1%, and 5% level of probability respectively. This implied that farmers' socio-economic characteristics have a lot of bearing on their ability to partake and utilize the technology. Education has always been known to play positive role in adoption and utilization of innovations among farmers. Sale *et al* (2016) suggested that as farmers education level improves, they are likely to utilize a technology. Source of information (1%) was highly significant and positively related to utilization, showing that majority of the respondents received information about the technology from multiple sources, such as media, fellow farmers and processors, NRCRI, ADP-Extension agents, cooperative societies among others. This also confirms that farmer's information sources were significantly related to their awareness of odourless cassava fufu processing technology in the study area (Adeleye *et al*, 2016). This concurs with the submission of Bamidele *et al*., (2015) that experience influenced the adoption of new cassava cultivates and value addition technologies.

Table 4: Tobit Regression estimates of the determinants of utilization of odourless cassava fufu in Abia and Imo states

Variables	Abia State	Imo State
Sex	-.1426752(0.007**)	-.1533439(0.473*)
Household size	.2345628(0.035*)	-1.819465(0.632)
Education	.25911876 (0.046*)	2.7402(0.036*)
Experience	.3253737 (0.045*)	.3150691(0.004***)
Source of Information	.0675293 (0.001***)	.2710157(0.030**)
Cassava Output	.0475135 (0.884)	2.256521(0.033**)
Chi^2 (X^2)	20.36***	25.76***
Prob>	0.0048	0.0087
R^2	0.457	0.665
Log Likelihood	-11.57607	-153.63775

Source: field survey, 2021. Note: Figure in parenthesis represent t-ratios; ***= significant at 1% level, **= 5% and *= 10%

CONCLUSION

The study revealed that households in Abia and Imo states use almost same methods in processing odourless cassava fufu. TME 419 was revealed to be the massively used and preferred variety for processing odourless cassava fufu in the two states. However, poor extension visit, high cost of the technology and undesirable traits some of the improved varieties possession are the very serious constraint to utilization of odourless cassava fufu in the two states. The respondents' socio-economic characteristics have a lot of bearing on their ability to partake and utilize the technology. Therefore, the study recommended the use of more channels of communication in technology dissemination in other to get the target goal desired by the developers of the technology and there is need to revive the extension services programme for appropriate and effective technology dissemination and follow up.

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Performance Analysis of the Cassava Producers in Abia State, Nigeria

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ABSTRACT
The study analyzed the performance of the cassava producers in Abia State, Nigeria. A multi-stage random sampling procedures was used to select 120 cassava producers with the use of a structured questionnaire, to collect primary data. Data collected were analysed with cost and returns model and ordinary least square (OlS) regression model. The cost and returns result shows that variable costs accounted for a very large proportion (96%) of the total cost of cassava production. The OLS regression result showed that farming experience, distance to the nearest market, quantity supplied of cassava, cooperative membership, household size and farm size influenced the profit level of the cassava producers at 10%, 5% and 1% levels of significance respectively. The study recommends cassava producers to form more cooperatives in order to enjoy credit facilities, increase their performance in cassava production and high profit in the cassava business.

Keywords: Cassava producers and Performance Analysis

INTRODUCTION

Farmers participating in the food market are a byproduct of progress poverty (Olwande and Mathenge, 2011). Farmers must have access to production technology, as well as appropriate private and public goods, as well as upgraded technologies. Ensuring widespread low-cost access to a competitive, well-functioning market necessitates large governmental investments funded by taxes or assistance flows, as well as proper institutional, endowment, and pricing. Primary producers cannot add value to their products due to socioeconomic, economic, environmental, and technological constraints. As a result, low manufacturing efficiency and product diversification has been limited. Furthermore, farmers' insufficient capital development may have hampered farm and household revenues. Cassava production and marketing are difficult for smallholder farmers. This could help smallholder farmers overcome obstacles along the cassava value chain. According to Achem *et al*. (2013), cassava root processing and value addition are required to extend shelf life (rots within 3-4 days of harvest), improve nutritional content (low in other nutrients, particularly proteins), and convert cassava root into other goods. Even in years of normal rainfall, some farmers are net purchasers of food, while others are neither buyers nor sellers. There is a price disparity between rural and urban consumers and producers. This implied that although cassava processing needs huge capital investment in the processing equipment at the initiation of the enterprise, however, once established, processors normally operate at optimum level hence enjoying the economies of scale. Despite farmers' difficulties in reaching markets, few studies on analyzing the performance of cassava producers in Nigeria and Abia state have been conducted. The specific objectives of the study were to determine the performance of the producers regarding their cost and returns and examine factors influencing the profit level of the cassava producers

METHODOLOGY

This research was carried out in Abia State. This study's population included all cassava farmers who produced tubers and processed tubers for market. The respondents for the study were chosen using a multi-stage sampling technique. First, one local government area from each of the three agricultural zones was chosen. Four autonomous communities were chosen from each of these local government areas, for a total of twelve communities. Two villages were chosen from each community, for a total of 24 villages. Ten cassava farmers producing for market were chosen from these villages, resulting in a total of 240 producers. As a result, a total of 240 respondents were used in the study. The primary data were collected directly from the field survey using well-structured questionnaires. In the data analyses, cost and returns model was used to analyzed objective three (3) which is to estimate the cost and returns associated with cassava production. The cost and returns model is given as:

NR= TR – TC

Where:

NR = Net Returns (₦)

TR = Total Revenue (returns) from the cassava enterprise

TC= Total Costs (₦)

N/B: TC = TVC + TFC

TVC = Total Variable Cost; TFC = Total Fixed Cost

N/B: Equation 3.3 was analyzed for both cassava producer

Objective five (5) which is to examine the factors influencing cassava producers and processors' level of performance was realized using the multiple regression analysis. The four functional forms (Linear, Semi-log, Cobb-Douglas and Exponential) of the model were tried and the best fit selected. The model is specified implicitly below:

Implicit Form:

$Y = F(X_1, X_2, X_3, X_4, X_5, X_6, X_7,)$ .... (3.9)

Where:

Y = Net return in Naira

X_1 = Age of respondent in years

X_2 = Level of education in years

X_3 = Farming experience in years

X_4 = Purchase price in Naira

X_5 = Depreciation in Naira

X_6 = Selling price in Naira

X_7 = Quantity of product sold/month

ei = Error term

b_o = Slope

b = Co-efficient

RESULTS AND DISCUSSION

Performance analysis of the cassava producers

The result shows that cuttings accounted for about 42.4% of the total cost of production of cassava in the study area, followed by fertilizer (34.3%) while labour (8.4%) was the least. It is well known that cassava production is labour intensive. However, the lower cost incurred from labour may be related to the utilization of household members in farm activities, while hired labour was for augmenting the family labour. In general, variable costs accounted for a very large proportion (96%) of the total cost of cassava production. Fertilizer utilization in the area of study is generally high, either because of the importance of fertilizer in increasing yield or due to the poor nature of the soils as a result of continuous use. Agrochemical use is moderate, probably because of the disease resistant nature of the varieties planted.

Table 1: Performance analysis of the cassava producers

Cost items	Amount (₦)	%
Variable costs		
Stem (₦)	61381.67	42.4
Fertilizer (₦)	49716.67	34.3
Agrochemicals (₦)	15350.27	11
Labour (₦)	12206.46	8.4
Total variable cost (TVC)	**138655.28**	**96**
Depreciation (₦) **(TFC)**	6164.58	4
Total cost, TC = TVC+TFC	**144,819.86**	
Quantity sold (kg) (Q)	8155	
Average price/kg (₦)	80	
Total Revenue, TR = (Q*P)	652,400	
Profit (TR – TC)	**507,580.14**	

Source: Field survey, 2020

Factors Influencing the Profit level of the Cassava Producers

The Ordinary Least Square (OLS) was used to estimate the performance (profit) determinants of cassava producers (Table 1). The four functions of the multiple regression model were tried, and the lead equation (semi-log) was selected based on the statistical and econometric criteria. The model coefficient of multiple determination (R^2) of 0.817 implies that about 82% variation in the profit level of the cassava producers was explained by the independent variables included in the model. The F-ratio was significant at 1%, indicating the model's goodness-of-fit. The result showed that farming experience, distance to the nearest market, quantity supplied of cassava, and cooperative membership were positively related to the profit level of the cassava producers (all at 1% level of significance). In comparison, the household size and farm size were negative at 5 and 1% levels of significance respectively. The positive coefficient of farming experience suggests that farmers who are more experienced in farming are more profitable than less experienced. This follows that experience is a core requirement to farmers' profitability as it informs good decision making relating to the purchase of production inputs, resource utilization, market conditions, and general farm decisions. According to Lagat and Maina, (2017), experience helps processors better appreciate the benefits and increase their profits In addition, processors with more years of experience acquire the knowledge and skills necessary for choosing appropriate processing technologies. The result showed that distance to the nearest market unexpectedly had a positive coefficient on the profit level of the cassava farmers. This implies that farmers situated in locations far from the market stand better chances of making higher farm profits than those located around the markets. Furthermore, Sebatta *et al.*, (2014) found out that being nearer to the market made it easier to access buyers who offered better payments hence more market participation**.** Quantity supplied was positively related to the profit level of the cassava producers, indicating that the larger the quantity supplied for sales, the higher the profits, all things being equal. Given that demand remains unchanged, additional product units will imply more sales and, consequently, higher profits. This is more so when farmers create artificial scarcity of the product. According to Mussema and Daniel (2012), when farmers produce more, they are motivated to sell more, attracting higher profits. The coefficient of cooperative membership was positively signed, indicating that farmers who belong to cooperative societies earn higher farm profits than those who do not belong to farmers' associations. Cooperatives play decent roles in the development of agriculture, especially among rural and poor-resource-based farmers (Onyemauwa, 2012). Contrarily, the household size coefficient was negatively related to the profit level of the producers. This result implies that farmers with large households are less likely to make profits than those with limited household members. This confirms Abu et al.'s (2014) results, who argued that most of what the family produced is consumed with large family size. Farm size also showed an unexpected negative coefficient, implying that farmers with larger sizes make lower profits when compared to farmers with smaller farm areas for cultivation. It is generally accepted that the larger the farm area, the larger the output and consequently profits. Allocating more land for production increased the extent of market participation and the sales volume. However, farm size could pose a challenge to farm incomes when the farmers cultivate large land areas and fail to manage them properly by enforcing good cultural practices, despite heavy farm investments. Sabasi and Shumway (2014) argue that it could be attributed to managerial ineffectiveness as farms get large.

Table 2: Factors influencing the profit level of the cassava producers

Variables	**Linear**	**Exponential**	**Semi-log (+)**	**Double log**
Constant	-2671.823	12.116	-4611826.000	3.665
	(-0.379)	(23.548)***	(-3.516)***	(162.071)***
Age of farmers	19.290	-0.010	-232708.100	0.006
	(0.124)	(-0.840)	(-0.687)	(1.110)
Years of education	303.454	-0.016	34725.220	0.000
	(1.658)	(-1.229)	(0.635)	(0.513)
Farming experience	98.858	-0.022	364690.300	-0.001
	(0.699)	(-2.146)**	(2.959)***	(-0.467)
Depreciation	-0.062	0.000	-11637.170	0.000
	(-1.215)	(0.312)	(-0.343)	(0.589)
Household size	-1102.999	0.177	-277755.900	-0.002
	(-1.477)	(3.244)***	(-2.063)**	(-0.738)

Extension contacts	-62.361	-0.009	24873.320	0.000
	(-0.474)	(-0.939)	(0.595)	(0.660)
Farm size	2500.847	0.284	-343397.100	0.003
	(1.644)	(2.560)**	(-2.826)***	(1.291)
Distance to market	-1248.319	-0.045	194228.500	-0.002
	(-4.137)***	(-2.029)**	(2.726)***	(-1.302)
Quantity supplied	40.040	0.000	600301.100	1.000
	(947.445)***	(16.375)***	(16.446)***	(1589.206)***
Cooperative memb.	-315.529	-0.905	555367.800	0.001
	(-0.124)	(-4.851)***	(4.598)***	(0.353)
Credit access	6115.163	0.108	44631.630	0.002
	(2.390)***	(0.578)	(0.392)	(1.047)
Adjusted R^2	0.999	0.790	0.798	1.000
R^2	0.999	0.809	0.817	1.000
F-ratio	12.635***	41.620***	43.820***	10.251***

Source: Field survey, 2020. *,** and * = 1, 5 and 10% levels of significance**

CONCLUSION

The study concluded that a profit of 507,580.14 was made under cost and the variable costs accounted for a very large proportion (96%) of the total cost of cassava production. The OLS regression result also showed that farming experience, distance to the nearest market, quantity supplied of cassava, cooperative membership, household size and farm size influenced the profit level of the cassava producers at 10%, 5% and 1% levels of significance respectively. The study recommends cassava producers to form more cooperatives in order to enjoy credit facilities, increase their performance in cassava production and high profit in the cassava business.

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Determinants of Adoption of Loss Reducing Technologies among Rice Farmers in North- Central, Nigeria

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ABSTRACT

The study was designed to examine factors that determine the adoption of selected loss reducing technology among rice producers in north-central Nigeria. Three hundred and seventy two (372) rice farmers were randomly selected through a multistage sampling procedure. Data collected through the use of structured questionnaires were analysed using Multivariate Probit. Various factors that promote the adoption of loss reducing technologies in North-central Nigeria include: off farm income, the amount of credit accessed by the farmers, being married, years spent in school, contact with extension agent and being from the derived savanna agro-climatic zone of Nigeria. Being a native of the study area, the presence of economically active members in the household and the proximity of the farm from the major road are other factors which promote adoption off loss reducing technologies. Based on the findings, the study recommends that the government as a matter of priority invest in and/or improve on institutional infrastructures – schools, roads, extension services, banks and other credit facilities to enhance farmers output. There is also the need to encourage farmers to attain some level of education as well as supplement their income by engaging in other income generating activities to improve in their farming activities and consequently on their food security.

INTRODUCTION

The food situation in Sub-Saharan Africa (SSA) over the past few decades has been an issue of major concern to both national governments and international development agencies. The incidence of hunger, poverty and undernourishment in the region are on the increase thus putting the region at risk of food insecurity. Issues relating to agricultural production and production incentives, policies, climate change, postharvest technologies and other economic factors are some of the major factors affecting food supply in the region (De Graaf *et al*., 2011; Sasson, 2012; Mahamat 2020).). The situation is further complicated by rapid increase in population (Mahamat 2020) and losses in the food value chain (Danbaba *et al.*2020)

With an estimate population of 200 million people Nigeria rely on import to compensate for shortfalls in domestic food supply particularly in rice a major staple food which is consumed across all the geopolitical zones and socioeconomic classes. This has become imperative as a result of supply demand gap, population growth among other factors identified to have aggravated rice self-sufficiency in Nigeria. Sanusi (2019) reported that Nigeria spend the sum of N7.92 trillion on importation of agricultural goods annually and rice alone account for N0.59 trillion. Shahandeh (2021) reported that about 1.8 Million Metric Tonnes (MMT) of rice was imported into Nigeria in 2020/2021 which is a decrease from the preceding years (2018 and 2019) where an average of 2.3 MMT of rice was imported annually (PWC 2021). To ensure self-sustenance and attain food security, local production must necessarily and significantly increase to meet the demand. Equally important is the adoption of relevant technologies by value chain actors; the absence of which has contributed to huge food losses over the years.

Statistics shows that losses in rice are increasing in spite of governments' interventions and policies. Kok and Snel (2019) reported that in Nigeria, about 35% of rice is lost from harvest to end of processing - the two points of losses are at harvest (12%) and threshing (11%). This is not surprising as post-harvest infrastructures are lacking /and or inadequate (Atibioke *et al*., 2012; Ndukwe *et al*., 2015, Danbaba *et al*/. 2020). Losses will remain a problem even in the presence of abundant technology when the technologies are not adopted by individuals who are the end users. Therefore, to improve production and consequently the farmers welfare in the rice subsector, it is imperative to examine rice production in Nigeria with emphasis on the adoption of loss reducing technologies in rice production.

The objective of this study is therefore to determine factors that promote the adoption of loss reducing technologies by rice producers.Given the large figures on importation, a reduction of food losses will reduce importation, encourage local production, lower prices for consumers and at the same time, increase farmer's income (IRRI, 2012; Berdu and Motunrayo, 2020). This will have far reaching beneficial implications for self-sufficiency in rice for the country, food security, income enhancement and poverty reduction for rice farmers and their households.

MATERIALS AND METHODS

This study was conducted in the derived and southern guinea savannah agro-ecological zones of Nigeria(North-central zone), three states of Benue, Nasarawa and Niger where chosen as they are ranked among the main rice producing States in Nigeria (NCRI, 2019). The respondents were drawn in a multi-stage sampling process, 232 farmers were selected and interviewed. Primary data obtained from farmers, through the use of structured questionnaires were analysed using the multivariate Probit.

The specific form of Multivariate Probit model is given as:

$$Y_{ik}^* = W_i' \beta_k + \varepsilon_i \qquad (k = CH, CV, IG, AWD, WH, RI, IPM) \qquad (1)$$

Where:

Y_{ik}^* = The net benefit that the farmer derives from the adoption of kth loss reducing technologies – combined harvester (CH), improved crop variety (CV), irrigation (IG), alternate wet and dry (AWD), water harvesting (WH), residue incorporation (RI), and integrated pest management (IPM)

W_i = observed household and socio-economic characteristics

ε_i = error term

β_k = unknown parameters to be estimated

Using the indicator function, the unobserved preferences in equation (1) translate into the observed binary outcome equation for each choice as follows:

$$Y_{ik} = \begin{cases} 1 \; if \; Y_{ik}^* > 0 \\ 0 \; otherwise \end{cases} \qquad (2)$$

Equation (1) is a system of k equations as shown in equation 3 below;

$$Y_{1k}^* = \beta_1' W_{1i} + \varepsilon_{1i} \quad Y_{1k} = 1 \; if \; Y_{1k}^* > 0, Y_{1k} = 0 \; otherwise$$

$$Y_{2k}^{*} = \beta_2' W_{2i} + \varepsilon_{2i} \; Y_{2k} = 1 \; if \; Y_{2k}^{*} > 0, Y_{2k} = 0 \; otherwise$$
$$\vdots$$
$$Y_{Nk}^{*} = \beta_k' W_{ki} + \varepsilon_{ki} \;\; Y_{Nk} = 1 \; if \; Y_{Nk}^{*} > 0, Y_{Nk} = 0 \; otherwise$$

Variables that were hypothesized to affect Farmers' adoption decisions

- Dependent variables;

Y_1 = adoption of combined harvester (1 if adopted, 0 otherwise),
Y_2 = adoption of improved crop variety (1 if adopted, 0 otherwise),
Y_3 = adoption of irrigation (1 if adopted, 0 otherwise),
Y_4 = adoption of alternative wetting and drying (1 if adopted, 0 otherwise),
Y_5 = adoption of water harvesting (1 if adopted, 0 otherwise),
Y_6 = adoption of Residue incorporation as manure (1 if adopted, 0 otherwise),
Y_7 = adoption of (IPM) Integrated Pest Management (1 if adopted, 0 otherwise).
Independent variables hypothesized to affect Farmers' adoption of postharvest technologies
W_1 = age (years),
W_2 = age squared,
W_3 = gender (0 if male, 1 if female),
W_4 = marital status (1 if married, 0 otherwise),
W_5 = farm size (hectare),
W_6 = dependency ratio (measured as proportion of household members that were not working to members who were working),
W_7 = off-farm income (Naira),
W_8 = nativity (1 if a native, 0 otherwise),
W_9 = extension contact (1 if respondent had contact, 0 otherwise),
W_{10} = amount of money borrowed (Naira).
W_{11} = membership of cooperative society (1 if a member, 0 otherwise),
W_{12} = economically active members of the household (number).

RESULTS AND DISCUSSIONS

Determinants of loss reducing Technology Adoption in Rice Production

As shown on Table 1 the likelihood ratio test (l = 182.75, $p<0.05$) suggests that the MVP suitably fits the study data. Consequently and as evident by the determinants of correlation (ρ), the null assumption of zero correlation between the covariance of the error terms across the adoption equations is rejected. The correlation coefficients show non-zero correlations throughout the model estimations; further justifying the choice of MVP for this objective. This implies that rice technology adoption decisions among rice farmers in the study area are jointly explained by certain socio-economic variables. A positive coefficient of correlation shows that these joint decisions are complementarity in technology adoption decision. This suggests that unobservable factors that increase the probability of adoption of a given technology also increase the adoption of another as found in Ashfaw *et al*. (2016), Kassie *et al*. (2015), Kahman (2015), Mulwa *et al*. (2017). Conversely, an inverse relationship indicates substitutability of rice technologies.

Table 1: Determinants of loss reducing Technology Adoption in Rice Production

Variable	Adopt Improved Variety		Combined Harvester		Retained Residue		Irrigation		AWD		Water Harvesting		IPM	
	Coef	Z	Coef	Z	Coef	Z	Coef	Z	Coef	Z	Coef	Z	Coef	Z
Age	0.0142	0.23	-0.012	-0.11	0.0378	0.62	0.00977	0.12	-0.02609	-0.47	0.051374	0.78	0.02998	0.54
Age Squared	-0.0001	-0.18	3.11E-05	0.02	-0.0006	-0.85	-0.00029	-0.33	0.000382	0.64	-0.00089	-1.19	-0.0003	-0.57
Sex	-0.4321	-0.7	-3.8889	-0.02	-0.5224	-1.03	-0.14683	-0.24	0.053612	0.12	-0.02756	-0.06	0.3201	0.77
Single	0.0556	0.22	-4.6078	-0.02	-0.1446	-0.59	-0.11574	-0.36	0.210828	0.91	0.156077	0.65	0.2793	1.33
Married	1.0252**	2.2	-0.8644	-1	0.716	1.59	0.151494	0.24	0.7308262*	1.7	-0.07959	-0.16	-0.5281	-0.95
Schooling Year	0.0369**	2.16	0.0761***	2.47	0.0191	1.27	0.006959	0.34	0.026052	1.62	0.015711	0.99	0.0081	0.52
Household member	0.1124	1.35	-0.0705	-0.53	0.2628***	3.29	-0.04085	-0.4	0.038664	0.46	0.088408	1.08	-0.066	-0.8

Dep. Ratio	-0.4713	-0.77	-1.238	-1.59	0.0807	0.14	-1.0409	-1.65	0.303674	0.49	-0.63502	-1.14	-1.571***	-2.78
Farm size	0.0112	0.7	-0.0323	-1.08	-0.0014	-0.1	0.009267	0.54	-0.02253	-1.34	0.018845	1.52	0.0035	0.25
Off-farm income	1.88E-07	0.27	-1.10E-07	-0.07	2.32E-08	0.04	0.213116	0.91	-1.80E-07	-0.32	0.0000133*	1.74	-1.03E-06	-1.39
Coop. Society	0.0323	0.33	-0.0126	-0.08	0.01047	0.12	-0.11829	-0.89	0.102571	1.11	-0.2563298**	-2.17	-0.0092	-0.1
Amount borrowed	2.04E-07	0.5	4.40E-07	0.76	-8.21E-07	-1.49	-3.70E-07	-0.46	5.20E-07	1.4	0.00000083**	2.08	-1.15E-07	-0.25
Native	0.105	0.42	-0.9623	-2.55	0.5023**	1.95	-0.07453	-0.24	0.322572	1.28	0.359157	1.43	0.2466	0.99
Extension contact	0.4805***	2.33	-0.1874	-0.6	0.1231	0.68	-0.1462	-0.62	0.4878102**	2.48	0.254402	1.36	0.1152	0.62
Road	0.033	1.16	-0.0812	-1.14	0.0530	1.83	-0.00933	-0.26	-0.02063	-0.63	-0.01727	-0.62	-0.0442	-1.2

Derived	0.7730***	3.44	-0.3324	-1.04	0.5370***	2.71	-0.03174	-0.12	0.194354	0.91	0.191505	0.94	0.2672	1.26
Constant	-2.3561	-1.55	0.5735	0.22	-2.638102	-1.85	-0.20458	-0.11	-1.7253	-1.25	-1.77078	-1.19	-0.6732	-0.51
Wald $\chi^2(144)$	182.75		-	-	-	-		-	-	-	-	-	-	-
Log-likelihood	-779.141		-	-	-	-		-	-	-	-	-	-	-
χ^2	0.016	-	-	-	-	-		-	-	-	-	-	-	-

i Determinants of the Use of Improved Variety in Rice Production.

Farmers who were married had a higher probability of adopting improved rice varieties than their counterparts who have never been married. Farmers who had contact with extension agents had higher probability of adopting improved rice variety than farmers without contact. Furthermore, rice farmers in the derived savannah ecological zone are more likely to adopt improved rice varieties than farmers in other rice production ecological zones in North-central Nigeria

ii **Determinants of the Use of Combined Harvester in Rice Production**

Educated rice farmers were highly probable to adopt combined harvester (for harvesting) in rice production operations. Moreover, the positive effect of education on improved rice variety adoption will likely bring about higher yields which might inform the decision to use better technologies to adequately manage a bumper harvest. However, native farmers (indigenes of farming communities) were found to be probably more apt to adopt combined harvester technology. This may be connected to the fact that the use of these machines require proper and specific field preparation to allow access to the farm for harvest and being that the cost of implementing new practices usually yield long term profits rather than short term profits (Rodrique *et al*., 2013); this being the case, non-natives who had no claim of ownership to land would not want to invest heavily on such lands (in form of making such lands accessible to farm machinery to work on) since the short term benefit may not be cost effective.

iii Determinants of Retained Residue Practice in Rice Production

The number of economically active members in a household increased the probability of adopting the technological practice of retaining and incorporating residue into the soil rather than burning. While this practice is in itself a relatively cheap method of soil nutrient management (in terms of cost), households with more economically active members tend to have the means to pay the additional cost of labour associated with the use of the technology. Native farmers had a relatively higher probability of using retained residue than non-native farmers. This may be that native farmers have more claims to /ownership of land than non-natives, and being that nutrients from refuse are slow releasing therefore the benefits are long term.

Non-natives therefore did not have the motivation of using this technique in enriching the soil particularly if the land is leased on short term basis. Natives would therefore not hesitate to adopt technologie s that may require long term returns on investment. This result is in line with the findings of Teklewold *et al*. (2013), Asfaw *et al*. (2014). The shorter the distance of rice farm from motor-able road, the higher the probability of rice farmers adopting the practice of retained residue. This result is in line the result of the work of Asfaw *et al*. (2016) and Bizimana *et al*. (2002) who reported access to road as being a positive determinant in the adoption of technologies as cost associated with moving inputs and equipment over long distance is high.

Determinants of Practice of irrigation in Rice Production

Results further show that formal education increased the probability of rice farmers adopting irrigation on their farmlands. The likelihood of educated rice farmers adopting this technology is based on their exposure to useful information on the importance of water conservation practices and the associated advantages. This result is in line with the findings of Teklewold *et al*. (2013) and Asfaw *et al*. (2016) in the adoption of organic fertilizer and modern inputs. Nevertheless, irrigation is labour intensive and likely to increase total variable cost of production of a given rice farm; hence, rice farming families with higher dependency ratio are significantly not inclined to adopt the technology.

V **Determinants of Alternating Wetting and Drying (AWD) Practice in Rice Production**

Results in Table 1 show that married rice farmers tend to have a higher probability of adopting AWD relative to single farmers. Being married may suggest availability of household labour which could help in farm operation particularly where it involves the opening and closing of bonds around the plots when water is needed and not needed respectively. The chances of adopting AWD also increased significantly with farmers-extension agents/services contact.

v. Determinants of Practice of Water Harvesting in Rice Production

Income from participation in off-farm activities is observed to drive water harvesting technology adoption decision among rice farmers. As off-farm income rises, on the average, farmers' adoption tendencies increased; this is contrary to the findings of Mulwa (2017), who reported a negative relationship between off-farm income and adoption of technologies. This result justifies the assertions that household income diversification improve farmers' credit constrained conditions regarding agricultural technology adoption and farm production expansion. Similarly, effective borrowing for farm production engagement supports technology adoption; thus, the probability of adopting water harvesting technology increased with increase in the Naira amount a rice farmer was able to borrow from formal and informal sources. This is expected as credit is reported to enhance adoption (Mariano *et al*., 2012; Uaiene *et al*., 2009). Contrary to expectation, however, rice farmers who were members of a cooperative society had lower probability of adopting water harvesting technology than non-cooperator farmers. Perhaps cooperatives members have access to better irrigation facilities therefore are not drawn to the idea of make shift facilities like harvesting water in ponds for cropping.

Determinants of Integrated Pest Management (IPM) Practice in Rice Production

Household dependency ratio of farmers was found to lower the adoption of IPM in rice production significantly. Rice farmers from households with relatively large number of dependents scarcely adopt IPM in rice pest control. While IPMs in themselves are not particularly cost ineffective, the need to combine different approaches, each of which involves individual cost implications, may be a reason farmers who have higher economic pressure on their disposable income were unable to explore the benefits of IPM.

CONCLUSION

Various factors promoted the adoption of loss reducing technologies in rice production in the study area: being married, Years spent in school, contact with extension agent', being from the derived savanna agro-climatic zones, being a native of the study area, the presence of economically active members in the household, the proximity of the farm from the major road. Other factors which enhanced the adoption include, off farm income and the amount of credit accessed by the farmers. From the forgone results being that factor such as education, contact with extension agents, credit, other sources of income, access roads are determinants to the adoption of loss reducing technologies the study recommends that the government as a matter of priority invest in and/or improve on institutional infrastructures – schools, roads, extension services, banks and other credit facilities to enhance farmers output. There is also the need to encourage farmers to attain some level of education as well as supplement their income by engaging in other income generating activities to improve in their farming activities and consequently on their food security,

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Analysis of constraints to the use of climate change adaptation strategies among rice farmers in Kogi state, Nigeria

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ABSTRACT:
This study focused on the constraints to the use of climate variability/ change adaptation strategies in Kogi State, Nigeria. Multistage random technique was employed to select the location and the respondents. Descriptive statistics and Factor analysis were the analytical tools used in this study. Uncovering the constraints to the use of climate variability/ change adaptation strategies among crop framers is important to give a realistic direction in the development of farmer-inclusive climate policies in Nigeria. The factor analysis result showed that the major constraints that the farmers faced in climate change adaptation were public, institutional and labour constraint, irrigation technology constraints, inadequate credit and farm inputs constraints, cost of land constraints and facility constraints information constraint; access to climate information, off-farm job and credit constraint; and poor agricultural programmes and service delivery constraint. These findings pointed out the need for both the government and nongovernment organizations to intensify efforts on institutional, technological and financial support to enable them get access to farming inputs, friendly land tenure and information systems as effective measures to guide climate change.
Keywords: Climate change; Adaptation; Constraints; Factor Analysis; Kogi State Nigeria

INTRODUCTION:
The climate has changed, is changing, and will continue to change regardless of all human investments (Falaki., *et al* 2013). The impacts of climate change are expected to be more pronounced in the developing countries particularly in Sub-Saharan Africa because their livelihood is dependent on agriculture which is highly sensitive to climate change. Nigeria is already experiencing climate changes ranging from more frequent erratic rainfall, and unpredictable onset of rain and increasing air temperature thus threatening ecosystems, infrastructure food production and livelihoodsand adaptation efforts seems not to be providing adequate responsive solution to the problem due to adaptation constraints (Guodaar and Asante 2018).

Eboh (2009) argued that no matter the sustained efforts to reduce GHG emissions in the atmosphere, the potential adverse effects of the changing climate cannot be avoided therefore; the mitigating efforts to enhancing the sinks of GHGs will take time and can only happen to a limited extent. It is in regard of this that adaptation has become a basic condition in climate variability discourses. Adaptation can be viewed as reducing the severity of many impacts if adverse conditions prevail. Simon (2011) also viewed adaptation as actions targeting changes to lifestyles, livelihoods and lived environments in order to be better able to cope with environmental changes. Consequently, it focuses on the implementation of policies and changes in management activities, institutional settings and infrastructure that enable effective responses to climate change. .Adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate. Thus, the goal of an adaptation measure is to increase the capacity of a system to survive external shocks or changes. Thus, IPCC (2007) sees adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Ifeanyi-Obi*et al.* (2012) opined that, agriculture is practiced across a broad range of climates and environmental conditions which makes it necessary for any country to develop an array of adaptation options that will meet the different conditions of the different ecological locations of the nation.Consequently, knowledge of the adaptation methods on the side of smallholder farmers may make it better to tackle the challenge of climate change.

However, a lot of adaptations options have been tried by farmers, these adaptation strategies are in most cases not used in seclusion. Farmers can combine many options where necessary in order to achieve the desired result. Therefore, building up adaptation strategies to cope with the changing climate becomes the most realistic alternative for farmers to employ in fighting climate change menace (Ifeanyi-Obi *et al*., 2012).

How much one can hold climate responsible for changes in agricultural productivity in Nigeria, will for long remain a subject of research as long as other factors are at interplay. Thus, understanding farmers responses to climate variations and climate change are crucial in designing appropriate adaptation strategies.

However, to cushion themselves against potential welfare losses, small holder farmers need to recognize the changes already taking place in their climate and undertake appropriate investment in climate adaptation.

Owing to increasing climatic change and frequency of extreme events in Nigeria, it is exceedingly imperative to understand the human-environment interactions in a local context by exploring the effects of climate change on rural livelihoods and associated adaptation efforts. Also, many existing studies in Nigeria show the need for adaptation research but actual field-based studies on farm level adaptation are not common. Therefore, it becomes pertinent to examine the constraints to the use of climate change adaptation strategies among rice farmers using factor analysis as the central focus of this study.

METHODOLOGY

This study was carried out in Kogi States, Nigeria. Kogi State is located in the north central Nigeria. In order to select a representative sample of the respondents for this study, multistage and stratified sampling techniques were adopted. Kogi State is made up of four agricultural zones A, B, C and D respectively. The first stage involves selection of two local government area each from all the agricultural zones where rice is grown. Secondly, two (2) villages were randomly selected

based on the enumeration areas making a total of sixteen (16) villages. The communities include Aiyetoro and Iya (Ijumu), Iluke and Odoekpe (Kaba/Bunu)from zone A, Kpanche and Ikande (Bassa), Echa/Abejukolo and Bagana (Omalla) from zone B, Kakand and Eggan (Lokoja), Girinya and Kotonkarfi (Kogi) from zone C, Ejule and Aya (Ibaji), Igalamela and Owolikpa (Idah) from zone D. Sampling frame of households was generated using the 2006 population census enumeration area list. However, Taro Yamane's (1967) formula was used to generate the sampled size at 9% from each of the agricultural zones. Lastly, a total of one hundred and twenty three (123) rice farmers' were selected.
The primary data were obtained using questionnaire and interview schedules. Data collected were on socioeconomic characteristics, adoption strategies and constraints faced by rice farmers. Data were analyzed using descriptive statistics and factor analysis.

Model Specification
Factor Analysis Model
Factor analysis provides a geometric representation that allows for a visual description of behavioral relationships. Factor analysis model is thus specified as:
The FA theoretical model applied in this study is expressed in the matrix:
$X = \Lambda f + e$
Where
x = the vector of n observable variables,
f = is the vector of m unobservable factors,
Λ = is the loading matrix of the order nfm and
e = representing the error vector of nxl
The KMO index and the Bartletts test at 0.00 significant levels were used as the basis for selecting the underlying factors that explained the data. For this study, only variables with factor loadings of ±0.4 and above were considered and used in naming the factors. The number of factors to be retained was on the basis of Latent root criterion (eigenvalue criterion) and the screen plot. The communalities represent the relationship between the variables and all other variables. However, the communalities above 0.3 were used to further confirm that each item shared some common variance with other items and thus ensures the adequacy of the data for the application of the factor analysis.

Table 1: Sample distribution of respondents by zones in Kogi State

Zones	LGAs	EAs	Sample Frame	Sample size
A	Ijumu	Aiyetoro	11857	7
		Iya	8302	5
	Kabba/Bunu	Iluke	8675	5
		Odoepe	5229	3
B	Bassa	Kpanche	13202	8
		Ikande	18860	12
	Omalla	Echa/Abejukolo	20398	12
		Baganna	11656	7
C	Lokoja	Kakanda	17698	11
		Eggan	15731	10
	Kogi	Girinya	10357	6

		KotonKarfi	11510	7
D	Ibaji	Ejule	17220	11
		Aya	12054	7
	Idah	Igalaogba	9693	6
		Owolokpa	8616	5
Total			**189402**	**123**

Source; 2006 National Population Census Figures

Table 2 revealed the adaptation strategies adopted by rice farmers. A number of adaptation options used by famers have been explored. Accordingly, the following adaptation strategies have been identified as a prominent adaptation strategies used in the study area. These are identified by considering the number of frequencies of these adaptation strategies among farmers as compared to all other options analyzed. It is found that farmers are using change of crop variety (57.69%), adjustment of time of operation (52%), crop diversification (25%), diversification to off-farm enterprise (22%), soil and water management (43.9%) andchange in cultural practices(41.56%) which accounts the response of sample households respectively to reduce the negative impact of climate change. Majority (57.69%) of the farmer decided to change crop variety is to enable cultivate three times within a year while the decision to change the time of farm operations is because of flood which usually comes at the peak of operation.

Table 2: Adaptation strategies used by smallholder farmers to deal with climate variability stresses in Kogi State

Adaptation strategies	Number of respondents(n=123)	Percent (%)*
Change in timing of operation	86	69.91
Change in crop variety	80	65.04
Crop diversification	55	44.71
Diversification to off-farm enterprise	30	24.39
Change in cultural practices	62	50.40
Water and soil conservation	43	43.95

Source: Field survey 2018

* Percentages cannot be added to 100 since a farmer can employ more than one adaptation strategy at a time

RESULTS AND DISCUSSION

Table2 revealedclimateadaptation constraints of rice farmers' in Kogi State, Nigeria. The data showed that five (5) factors were responsible for the challenges rice farmers confronted with in adapting to the changing climate. These factors include (Factor 1) shortage of labour, poor technical know-how and widespread nomadism constraints. Factor 2; high cost of inputs and low education constraint. Factor 3; extensive rain-fed agriculture and low migration constraints. Factor 4; poor access to extension service delivery and limited land availability constraints while Factor 5; inadequate information on climate change and poor access to inputs supplies constraints.

However, after the rotation factor 1 accounted for 14.9% of the variance, factor 2 accounted for 13.2%, factor 3 accounted for 11.7%, factor 4 accounted for 11.4% and factor 5 accounted for

10.9%. Therefore, the true factors that were retained explained 62.1% of the variance in the 15 constraining variables.

Table 2: PCA constraints of rice farmers to climate adaptation strategies in Kogi State, Nigeria

	Constraints	Components					Communality
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
1	Shortage and high cost of labour	0.737					0.626
2	Poor technical know-how of the farmer	0.685					0.729
3	Widespread nomadism	0.524					0.495
4	High cost of farm inputs		0.788				0.598
5	Low education rate		0.783				0.689
6	Extensive rain-fed subsistence agriculture			0.796			0.549
7	Low migration level of the rice farmers’			0.721			0.712
8	Poor access to extension service delivery				0.753		0.367
9	Limited land availability				0.637		0.663
10	Inadequate information on climate change					0.743	0.639
11	Poor access to input supplies					0.678	0.759
	Eigenvalue	1.881	1.428	1.282	1.176	1.058	
	Percentage (%) of total variance	17.103	12.982	11.658	10.694	9.621	
	Cumulative (%)	14.873	28.070	39.752	51.188	62.058	

Source: Field survey 2018

Under factor 1 (labour constaints), the specific issues that loaded high were shortage of labour to assistance rice farmers in adapting to climate adaptation strategies (0.737), poor technical know-how of farmers (0.685) and wide spread nomadism (0.524). Labour is one of the factors that drive agricultural growth and development in Nigeria and in the entered Africa countries and as such labour shortage has policy implications on agricultural productivity in rice producing communities in Nigeria. Labour shortage could be as a result of migration to urban areas and shift from farming by younger community members into other activities. Labour cost was also a daunting challenge to the farmers. The ability of rice farmers to hire labour on a farm during the entered production stages has potential challenge on productivity. Thus, smallholder farmers' cannot adapt to climate change adaptation strategies in the area. Ozor *et al*., (2010) affirmed to this assertion in the study; barriers to climate change adoption among farming households of Southern Nigeria.

Personal constraints: The variables that loaded high under factor 2(personal constraints) include high cost of farm inputs (0.788) and low education among rice farmers (0.783). The high cost of farm inputs like the agro-chemicals (herbicides, pesticides, fungicides) fertilizers, tractors could eventually lead to a high cost of food production, hence affecting food security. All these variables suggest scarcity of resource inputs, which raise their prices beyond the reach of the farmers. This could pose threats to the coping strategies of the farmers as noted by Ozor *et al*., (2010), climate change might constitute significant addition to the stresses already borne by farmers, thus, adapting to it might be beyond their resource capabilities. This agrees with the findings of Antwi-Agyei *et al*., (2013) who identified lack of climate risk information and early warning systems due to poor meteorological facilities and equipment as having adverse effects on farming activities in Ghana.

The variables thatloaded high under factor 4 (poor extension service delivery directed to meet climate change adaptation strategies (0.753) and limited land availability (0.637). /Inadequate extension officers coupled with poor extension service delivery hinders proper extension services. Information dissemination on climate variability and application of right extension technologies are very vital in providing early warning signals and reorienting the mindset of farmers towards sound adaptive capacities. This corroborates with the findings of Otitoju et al., (2016) that lack of/or inadequate extension programme is a constraint to the use of climate change adaptation strategies among food crop in South-West Nigeria. Guodaar & Asante (2018) also affirmed that farmers' access to extension service is a major determinant of swiftness of adoption procedures to climate change.

Regarding factor, 5 the variable that loaded high include inadequate information on climate change (0.743) and poor access to input supplies (0.678). Otitoju and Enete (2016) affirmed that information problem could pose serious challenges to farmers' adaptation strategies as they may not be aware of current developments concerning climate change and the necessary readjustments required. Furthermore, the poor anticipation by government agency on how climate will affect farmers' live now and in future, leading to inability to make provisions for uncertainty, is a result of poor funding of the agricultural sector.

CONCLUSION AND RECOMMENDATIONS

This study revealed that the climate change adaptation strategies used in rice production were change of crop variety, adjustment of time of operation, crop diversification, diversification to off-farm enterprise, soil and water management andchange in cultural practices. The study also revealed that some farmers sometimes failed to employ any adaptive strategy in the event of climate variability risks.

The major factors that hinder rice farmers' adaptive practices were personal barriers, institutional and labour constraints, irrigation technology constraints, inadequate credit and farm inputs constraints, cost of land constraints and facility constraints information constraint; access to climate information, off-farm job and credit constraint; and poor agricultural programmes and service delivery constraint

There is complete need to take out and address these constraints encountered by trice farmers in adapting to the effects of climate change as this will have far-reaching implications on policy implementation that is geared towards food production and consumption. There is therefore the need for public and private financial institutions to provide farmers with some financial support to enable them get access to farming inputs, friendly land tenure and information systems as effective measures to guide climate change.

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Effect of sweet potato vine (seed) production technologies' adoption on the welfare of rural farmers in Abia State, Nigeria.

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ABSTRACT

The study was carried out to assess the effect of sweet potato vine (seed) production technologies' adoption on the welfare of rural farmers in Abia State. Data were collected from a sample of 60 farmers with the use of structured questionnaire. Frequencies, percentages and means were used for data analysis. The results showed that the majority (58.3%) of respondents were female, about 65% of the respondents fell within the age range of 31-50 years, 50% of the respondents had farming experience of between 11-30 years. It was also discovered that adoption of sweet potato vine (seed) technologies had positive effect on the welfare of the farmers particularly increased farm income of the respondents, which translated to improvement in their standard of living, expansion of their farms and it also impacted on their children's education and nutrition status of the farmers.

Key words: **Sweet potato, Vine (Seeds), Adoption, Welfare, Farmers**

INTRODUCTION

Sweet potato (Ipomoea batatas (L) Lam) is an herbaceous warm weather creeping plant belonging to the family Convolvulaceae and genus ipomoea (International Potato Centre (CIP) 2010). Sweet potato originated from South America. Sweet potato is a food and nutrition security crop grown in almost all Asian countries with China taking the lead, then Africa and Latin America (CIP,2009).Nigeria is one of the largest producers of sweet potato in Sub-Saharan African (SSA) with annual production estimated at 4.03 million tons per year with farm size of about 1.7mhaand yield of .3t/ha (FAO, 2018).Sweet potato is an important staple crop grown in all parts of Nigeria by small-scale farmers. The crop has moved up from the minor status to an enviable position of being the fourth most important root and tuber crop in Nigeria after cassava, yam and cocoyam. Sweetpotato vine (seeds) or planting materials refers to cuttings from sweet potato plant vines, they can be planted and are genetically identical to the mother plant. Plant breeders can also produce 'true seed' by fertilising a sweetpotato flower with pollen from another sweetpotato plant. Sweetpotato vines are used vegetative to propagate another sweetpotato plant. Some improved production technologies have been developed and disseminated by National Root Crops Research Institute for adoption and continuous use to increase sweet potato production in Abia state and by extension increase the income and well-being of the farmers. National Root Crops Research Institutes (NRCRI), Umudike embarked on rigorous and active research into the genetic improvement, production, processing, storage, utilization and marketing of root and tuber crops of economic importance in Nigeria NRCRI (2009). These research efforts have led to the introduction of improved varieties of sweet potato such as TIS 87/0087, TIS 2532, OP.1.13, TIS 8441, TIS 8164, Umuspo 1 and Umuspo 3 which are high yielding and resistant to disease and pest attack, also tolerant to prevalent pests, notably sweet potato weevil, Cylas spp and with wide adaptation across Nigeria (NRCRI, 2009).The components of the sweet potato production seed technologies are:20x10 spacing of rapid multiplication of sweet potato, Harvesting of vines at 8WAP first, then every 4weeks, planting on beds not on ridges or mounds using slanting method, Weeding at 4weeks after planting then rouging, Use of herbicide and pesticide and application of fertilizer at 4WAP. Adoption of improved sweet potato Vine (seed) technologies to achieve higher yield can directly affect income and welfare of farmers, food and nutritional security through changes in production patterns. Welfare of farmers relates to their standard of living, farmers' ability to afford the basic needs of life such as quality health care, housing, clothing, education and nutritious food. This study assesses the effect of sweet potato Vine (seed) production technology adoption on welfare of rural farmers in Abia state The objectives were to describe the socio-economic characteristics of farmers in the study area and to assess the effect of the technologies on welfare of rural farmers in Abia state

METHODOLOGY

The study was conducted in Abia State. The State has three Agricultural zones with 38 extension blocks and 27 circles (ADC,2019). These zones are Aba, Ohafia and Umuahia. . Multi stage and purposive sampling techniques were used to elicit information for the study. Three Agricultural zones of the state were involved in the selection of the respondents for the study. One block in each zone was purposively selected because of their involvements in sweet potato farming and the technologies have been disseminated to the area, giving a total number of three blocks. Two circles from each block were purposively selected for the same reason. Ten (10) farmers were randomly selected giving a total of 60 sweet potato farmers (vine multipliers). Primary data were used for the study and data were collected using structured questionnaires. Data were analyzed using descriptive statistics such as frequencies, percentages and five point likert scale strongly agreed (5), Agreed (4) Undecided (3), Disagreed(2) and Strongly disagreed(1).

RESULTS AND DISCUSSION

Socio-economic characteristics

The result in table 1 showed that Majority (65%) of the farmers fell within the age range of 31-50 years. This implied that young people of active age dominated the activities of sweet potato production technologies in the study area but younger female farmers were the most dominants of the practice. Majority (58.3%) of the farmers were female which implied that women were more involved in the production of sweet potato than men. The result also shows that majority (63.3%) of the farmers had household size of between 5-7 persons. This means that the farmers had relatively large-sized households since they believe that getting married and having children is an alternative source of labour to the usage of hired farmlands. The result also shows that most Farmers (70%) earn annual income of between sixty thousand ₦60,000 to two hundred and fifty nine thousand ₦259,000. A few of the farmers about 10% earned up to four hundred and sixty thousand naira (460,000) and above.

Effect of sweet potato seed technologies on the welfare of rural farmers

The result from table 2 revealed that increased income with mean (4.6) ranked first as the major effect of sweet potato seed technology adoption on farmers' welfare in the study area. Adoption of improved sweet potato seed technology is expected to lead to increased production and productivity and consequently improving farm incomes and hence household welfare. With increase in income, there will be positive change in socio-economic status of the farmers leading to improved standard of living in the study area. This is followed by improved standard of living which had mean (4.1) and ranked second as major and positive effect of sweet potato vine technology adoption on farmers' welfare. Obviously, farmers agreed that the moment their income increased, there will be commensurable improvement on their living standard and that of their households members which will manifest in every areas of their lives such as housing, clothing, health care services and education. Similarly, respondents identified expansion of farms with mean (4.0) as third major and positive effect of sweet potato vine technology adoption on farmers' welfare. In line with a prior expectation that when farmers expand their land or increase their farm size under sweet potato cultivation, it is expected that there will be increased yield which by extension increase the income of farmers and raising their living standard thereby impacting positively on the welfare of farmers. This finding was consistent with the finding of Diagne *et al*. (2009) and Mendola (2006) who found a significant positive difference in farm size between the technology adopters and non-adopters with the adopters cultivating larger farm size. However, the higher land area cultivated by the adopters, translated to increase in annual household income. Other major and positive effect to sweet potato seed technology adoption on farmers' welfare was training of children and wards with a mean of (3.9) ranked fourth, sweet potato vine technologies are able to send their children/wards to school and access quality health care. This result agrees with Anaglo *et al*. (2017) who discovered that majority of farmers with high levels of adoption (95.62%) demonstrated an improvement in the ability to pay children school fees compared with the majority of those with low levels of adoption. Another important of sweet potato vine technology adoption on farmers' welfare as reported by the farmers was acquisition of new properties with mean of (3.3). Finally is improved food and nutrition with mean (2.0) according to the respondents, this does not have major effect on farmers welfare. This is from the reasoning that sweet potato vine technology adoption will always translate to high yield which makes food available at all times in the farmers households but often times there are gluts when the sweet potato is in season making its price to be low in the market.

Table 1: Socio-economics characteristics of the respondents

Variables	Frequency(60)	Percentage(100)	Mean
Age			
21-30	3	5.0	43.7
31-30	29	48.3	
41-50	10	16.7	
51-60	12	20.0	
61-70	6	10.0	
Sex			
Male	25	41.7	
Female	35	58.3	
Level of education			
Non formal education	3	5.0	
Primary	4	6.7	
Secondary education	26	43.3	
Tertiary education	27	45.0	
Household size			
2-4	13	21.7	
5-7	38	63.3	5.8
8-10	9	15	
Estimated annual income after adoption(#)			
60,000-159,000	15	25.0	109500
160,000-259,000	27	45.0	
260,000-359,000	9	15.0	
360,000-459,000	3	5.0	
460,000 and above	6	10.0	

Table 2: Effect of sweet potato seed technologies on the welfare of rural farmers

Improved welfare	SA 5	A 4	U 3	D 2	SD 1	Sum	Mean
Increased income	44(220)	13(52)	-	3(6)	-	278	4.6
Improved standard of living	24(120)	26(104)	7(21)	3(6)	_	251	4.1
Expansion of farm	15(75)	38(152)	7(21)	-	_	248	4.0
Train your children/wards	21(105)	20(80)	16(48)	3(6)	_	239	3.9
Acquire new properties	15(75)	12(48)	12(36)	21(42)	-	201	3.3
Improved food and nutrition	18(90)	21(63)	14(42)	7(14)	_	209	2.0

SA (Strongly Agreed) A (Agreed) U (Undecided) D (Disagreed) SD (Strongly Disagreed) Field Survey, 2019.

CONCLUSION

The study investigated the effect of sweet potato vine (seed) technologies adoption on the welfare of rural farmers in Abia state. The result revealed that women were more involved in the activities of sweet potato vine production. Majority of sweet potato farmers were still in their middle active productive age with varying levels of education. . It was also discovered that adoption of sweet potato vine technologies had great effect on the welfare of the farmers particularly on increased farm income, which translated to improvement in their standard of living, expansion of their farms and it also impacted on their children education and nutrition status of the farmers.

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Analysis of Farm and off Farm Income Generation among Fadama and Non Fadama Users in Imo State

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ABSTRACT

The study examined the livelihood diversification strategies among Fadama and Non Fadama users in Imo State. Nigeria. Data used for the study were collected with the aid of structured questionnaire administered to 150 randomly selected Fadama users and 150 non-Fadama user making it a total of 300 questionnaires. Data were analyzed using descriptive statistics and net farm income model. Result of the analysis showed that farming activities is the major source of income generation among Fadama and non Fadama users in the study area, contributing 63.6% and 51.9% of Fadama and non Fadama users' total household income. Non-farm activities contributed 36.4% of the Fadama users' total household income. In the same vain, non-farm activities among non Fadama users contributed 48.1% of their total household income. Despite growing concern that farming alone may not provide sufficient income for sustainable livelihood, it still dominates income generating activities among Fadama and non Fadama users. It is therefore recommended that Government policies aimed at leveraging from donor assisted projects for agricultural purposes and income generation should eliminate factors that could create barrier for some farmers or community members from accessing such donor assisted projects.

Keywords: Farm, Off Farm, Income, Fadama, Non Fadama.

1.0 INTRODUCTION

The vast majority of poor households living in the developing areas rely on agriculture for their food, income, and livelihood (Dethier and Effenberger 2012; Larsen and Lilleør 2014). In Nigeria, agricultural sectors still constitute the source of employment and livelihood for about three quarters of the population and it is also the dominant activity in terms of linkages with the rest of the economy, plays important role in the livelihood and social- cultural system of the country. According to the Labor Force Survey for 2019, the agricultural sector employs 67million persons. 41.6% of the total labor force (Ashiru, 2019). Agriculture share GDP of 55% in 2019 (Adewale, 2020). According to (World-Bank, 2010), majority of the farm household populace either depend entirely on farming for survival and generation of income, or depend on farming to supplement their main sources of income. Agriculture is still the major sector upon which the majority of Nigeria's rural poor depend on for their livelihood, (Oladimeji, *et al*. 2014),

In recognition of the importance of the agricultural sector in Nigeria, the government has initiated and endorsed many national and international projects, programs and policies aimed at increasing farmers' income, supporting livelihood activities and thereby reducing poverty. Laudable among these programs is the National Fadama development programme. Fadama is a Hausa name for irrigatable land which is flood plains and low lying areas underlined by shallow aquifers and found along Nigeria's river systems. Fadama areas are typically waterlogged in the rainy season but retain moisture during the dry seasons. These areas are considered to have high potentials for economic development (NFDP II, 2014)

Imo State is among the states that benefited in both Fadama I, Fadama II, Fadama III and Fadama III Additional Financing whose development objective was to increase the incomes of users of land and water resources on a sustainable basis. It also seeks to reduce conflict among users and aims to address some factors that militate against the full realization of the potential benefits of agricultural production activities- poor development of infrastructure, storage, processing and marketing facilities (FADAMA III AF 2017).

Despite this laudable project, it has been established that Farming as a primary source of income has failed to guarantee sufficient livelihood for most farming households in developing countries (Babatunde, 2015, hence rural farming households have been found to diversify their income sources thus, allowing them to spread risk and enhance income generation, Maniriho and Nilsson (2018). More than 80% of the rural households in Nigeria relate their poverty status to problems in the agricultural sector and specifically to lack of inputs and not being able to afford inputs such as fertilizer and seeds. To overcome this problem, farm households often diversify their livelihood from farm into off-farm activities to earn income to finance farm investment in the absence of a functioning credit market (Nawoji et al., 2018). According to (Bola et al.2019). Non-agricultural income constitutes 40 - 45 per cent of farming household income across the developing world. Farming households in developing nations receive quite reasonable proportion of their incomes from off and on-agricultural employment and off and on-farm income, is income earned from non-agricultural sources either in wage-employment or self-employment (Mohammed et al., 2019).

Non-farm income generating activities include all economic activities in rural areas except agriculture, livestock, fishing and hunting. It includes all off-farming activities, processing, marketing, manufacturing, wage and causal local employment in the rural villages (Igwe, 2013). It encompasses all economic activities except the conventional crop production and livestock rearing (Agbarevo and Nmeregini, 2019).

Rural people have diversified their livelihood means and income earning portfolio across farm, non-farm and off-farm activities, (Agbarevo and Nmeregini, 2019). According to Musa and Kumilachew (2018), findings consistently show that incomes generated from off-farm activities ease the burden on agriculture as it enables households to have better incomes. Hence, they enhance food security as they manage food consumption fluctuations better than a household without such an activity (Hoang et al. 2014; Mishra et al. 2015). The push factors that may drive off-farm income generation includes the need to increase family income when farm income alone cannot provide sufficient livelihood (Nawoji et al., 2018).

Furthermore, the perceived advantage of off farm income generation is increasingly becoming important in the light of reiterated environmental, economic, farmers herder crisis, banditry and kidnapping affecting the rural areas of our countries. Thus, a thorough understanding of farm and off farm incoming generation among fadama and non fadama households is indispensable. This would help development institutions to review their strategies, so as to address the needs and problems of farming households.

This study, therefore, attempted to analyze the farm and off farm income generation among fadama and non- fadama users and their income share in the study area.

2.0 MATERIALS AND METHOD.

This study was conducted in Imo state, Nigeria which is among the states in Nigeria that benefited from the National Fadama Development project. Imo State lies between Latitude $5^0 10'$ and $6^0 35'$ North of the equator and between Longitude $6^0 35'$ and $7^0 31'$ East of the Greenwich meridian. The State has a population of about 3,934 million people disaggregated into 2,032 males and 1,903 million females (NPC, 2006). It is bounded on the East by Abia state, on the North by Anambra and Abia State, and on the West by Rivers State. The State is divided into 27 administrative units called Local Government Areas which are grouped into 3 agricultural zones viz Owerri, Okigwe and Orlu. Fadama II was implemented in 11 local government areas of the state, while Fadama III was implemented in 20 local government areas of the state. The population for our study encompassed the beneficiaries of Fadama II, Fadama III and Fadama III Additional financing and their non-beneficiaries. Multistage random sampling technique was used in the selection of the sample. In stage one, two Local Government Areas (LGAs) that participated in both Fadama II Fadama III and Fadama III additional financing were purposively selected from each agricultural zone. In the second stage, 5 Fadama community Associations (FCAs) were chosen randomly from each of the selected local government areas, thus giving a total of 30 Fadama Communities Associations. The third stage involved random selection of 5 Fadama user groups (FUGs) from each of the 30 Fadama communities Associations making a total of 150 FUGs. In the 4^{th} stage, a member of the Fadama user group (FUG) was chosen randomly from each of the selected Fadama User Groups, thus giving a sample size of 150 Fadama respondents. In order to study uniform number of parallel respondents, 150 non Fadama users were drawn randomly from the same thirty (30) communities where the Fadama community associations and fadama user groups were chosen (5 non Fadama users from each community), bringing the cumulative sample size of 300. Data were sourced both through primary and secondary methods. Primary data were obtained with the aid of structured questionnaire. Secondary data were obtained from relevant current literature. Data were analysed using Aggregate Net Household income (Y) = Net Cash Value + Net Imputed Value, to determine the income of the respondents and simple descriptive statistical tools to determine the income share of the respondents.

3.0 RESULT AND DISCUSSION

3.1 FADAMA, Farm and Non-Farm Activities

The distribution of Fadama by Farm and Non-Farm activities with income share is presented in Table 3.1.

Table 3.1: Farm and Non-farm activities engaged by Fadama users with their income share

Farm Activities	Aggregate income (₦)	No of participants	Income share	% income share
Crop	198257.7	142(95)*	0.354	35.4
Livestock	103049.2	71(47)*	0.184	18.4
Forestry	20161.8	9(6)*	0.036	3.6
Fishery	34723.1	20(13)*	0.062	6.2
Self-employment	98008.75	70(47)*	0.175	17.5
Non-farm Wage employment	102489.15	31(21)*	0.183	18.3
Farm wage employment	3360.3	5(3)*	0.006	0.6

Source: Survey data, 2021. Figures in parentheses are percentages * multiple responses.

The table showed that 95% of the Fadama users engaged in crop activities, contributes 35.4% of the aggregate household income of Fadama users in the study area. Livestock is another important farm income generating activity among the Fadama users. Hence analysis of the result suggests that 47% of Fadama users participated in livestock activities and generated 18.4% of the household income. The result also showed that 6% of Fadama users participated in forestry activities and generated 3.6% aggregate household income. Finally, 13% of Fadama users are involved in fishery activities and contributed 6.2% of aggregate household income. the table also showed that 47% of Fadama users participated in self employment with 17.5% income share, non farm wage employment among Fadama users' accounted for 18.3% of aggregate Fadama users household income with 21% of the households participating. Farm wage employment as a non farm income generating activity accounted for 0.6% of aggregate Fadama users' household income.

3.2 NON- FADAMA, Farm and Non-farm Activities

Table 3.2: depicts farm and non farm activities engaged by non-Fadama users with income shares.

Table 3.2: Farm and Non-Farm Activities Engaged by Non Fadama Users with their Income Shares.

Farm Activities	Aggregate income (₦)	No of participants	Income share	% income share
Crop	193029.31	146(97)*	0.413	41.3
Livestock	31782.07	28(18.7)*	0.068	6.8
Forestry	13554.12	12(8)*	0.029	2.9
Fishery	4206.45	5(3)*	0.009	0.9
Self-employment	107498.17	70(38)*	0.230	23
Non farmWage employment	84596.38	31(16)*	0.181	18.1
Farm wage employment	32716.83	5(14)*	0.070	7.0

Source: survey data 2021. Figures in parentheses are percentages * Multiple responses.

The analysis in Table 4.9 showed that 97% of non Fadama users engaged in crop activities and generates 41.3% of aggregate household income. The result also showed that 18.7% engaged in livestock activities and contributed 6.8% of aggregate household income. Forestry and fishery accounted for 2.9% and 0.9% income share with 8% and 3% participation respectively. The further showed that 38% of non Fadama users that engaged in self employment activities generated 23% of the aggregate houseold income. The data also showed that non farm wage employment among non Fadama users' accounted for 18.1% of the aggragate non Fadama usrs household income with 16% of households participating. Comparatively the results of analysis in Tables 3.1 and 3.2 seem to suggest that Fadama users participated more in wage employment activities than non Fadama users. This goes to show that those who benefited from Fadama project are not only poor resource farmers but also salary eaners. Non farm activities acounted for 36.4% of the total Fadama users' income and 48.1% of the total non Fadama users' income. This finding is similar to the work of Amanze et al. (2015) whose study showed that about 35% of rural incomes in Nnewi South stem from non-agricultural activities. The result of the analysis also showed that both Fadama and non Fadama users do not attach so much importance to fishery and forestry activities. This is evidenced from the number of participants in each of the activities. The finding showed that the major income generating activities for both Fadama and non Fadama users are crop and livestock activities. However, despite the degree of diversification among Fadama and non Fadama users, farm activities remain the main source of income generation. The difference in percentage of income generated from farm activites among Fadama and non Fadama users could be attributed to the grant for asset acquisition, capacity building, advisory services and input support given to Fadama users by the Fadama project. The findings of this study are in line with the work of Tijani et al (2014) whose report showed that Fadama users and non Fadama users participated and generated more income from crop activities than any other activity in a similar study in Kogi and Kwara States.

CONCLUSION AND RECOMMENDATION

Fadama and non Fadama users are involved in multiple sources of income generating activities simultaneously as a means of income generation. Fadama as community development project, boosted farming activities among her users, hence Fadama beneficiaries participated and generated more income from farming activities than Non- farm activities in the study area. Members of the community should actively participate in community development projects designed and sponsored by government and donor agencies that will enhance their income generation. Government and donor agencies during project design should eliminate factors that could create barrier for some farmers or community members from accessing such donor assisted projects.

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Determinants of participation in cassava value addition by smallholder cassava-based households in Benue State, Nigeria

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ABSTRACT
Cassava value addition is an important activity that has the ability to improve the financial earning capacity of farm households. Yet, little is known about the determinants of participation in cassava value adding activities by farm households. Thus, this study analyzed the determinants of farmers' participation in cassava value addition in Benue State. The primary data used was collected with the aid of questionnaire from the respondents selected using multi-stage sampling techniques. The data were analyzed using descriptive statistics and probit regression. The results of probit regression show that membership of cooperative society, access to extension agents, years of farming experience and number of working household members had direct significant influence on participation, while marital status indirectly influenced it. Policies that will encourage farmers to join cooperative societies and increase farmers' access to extension services are suggested.
Keywords: cassava value chain; farm households, determinants, probit regression

INTRODUCTION
Cassava is a nutty-flavored, woody shrub mainly cultivated for its starchy root vegetable or tuber. Native to South America, it is a major source of calories particularly for people in developing countries. The cassava tuber is drought resistant, can be grown on land where other crops do not do well, and requires little inputs. For these reasons, African small and poor farmers grow it widely as a subsistence crop. It is not known when Cassava was actually introduced into Nigeria but the diffusion of cassava can be described as a self-spreading innovation that at some point found its way into the country. Its ability to grow well in poor soils and withstand drought make it an ideal crop to cultivate in places where other crops struggle, and the crop thrives in Nigeria's soils. The Food and Agriculture Organization (FAO) estimated global production of cassava in 2014 at about 268 million tons out of which Africa produced about 54%. Nigeria alone produced about 55 million tons, which, also at an estimate, is about 21% of total global production.

Most of the cassava produced in Nigeria (88%) is used for human food, with over 50% used in the form of processed products. Other uses are in the form of animal feed and industrial raw material purposes (starch, ethanol). Cassava, especially in its value added forms, has the potential to increase farm incomes, reduce rural and urban poverty and help close the food security gap. Yet, it has been observed that the involvement levels of farmers in value adding processes especially cassava value chain activities is startlingly low (Ogunyinka et al., 2018). This could be attributed to a lack of standardized products and, low competitiveness within the commodity market, due to inadequate infrastructure and technology. This has led to the continued low production capacity and income. To this end, this study focused on the determinants of farmer households' participation in cassava value addition

MATERIALS AND METHODS

The study was conducted in Benue State, Nigeria. A three-stage sampling techniques was used to select respondents. The first stage was a purposive selection of two local government areas (LGAs) which are known for their high cassava production. The second stage was a random selection of 10 villages from each of the LGAs to give a total of 20 villages. The enumerators with the help of village heads helped in compiling the list of households in the selected villages. At the third stage, there was the random selection of respondents proportionate to the size of cassava-based households in each of the villages. Data was collected from them with the use of questionnaire. The data were analysed with descriptive statistics and Probit regression. While descriptive statistics was used to analyse respondents' socio-economic characteristics, their participation status in value adding activities was analysed with Probit regression.

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

The results of the socio-economic characteristics of respondents are presented in Table 1. The average age of respondents was 46 years (Isitor et al., 2017). The mean household size and annual income stood at 10 persons and ₦1,025,687 respectively. The mean year of farming experience stood at 19.68 (Isitor et al., 2017). The average distance between farmers' residence and the nearest market was 3.63 Km. About 89% of the respondents were married with more than three-quarter of them being males. About 16% had no formal education (Adewuyi et al., 2013). Less than halve of the respondents owned the cassava land they cultivated. Only about 72% of the farm households were able to access credit in the year preceding the survey. This is contrary to the submission of (Adeyonu et al., 2017). More than three-quarter of them were members of cooperative society (Osuji, 2019). While about 59% of them had access to extension services, the remaining 41% could not access extension services. About 65% had access to electricity for a minimum of five hours daily, while the remaining were denied access.

Table 1. Socio-economic characteristics of the respondents (Continuous variables used in probit regression)

Variables		Unit	Mean		Standard deviation
Age		Years	46.09		9.34
Household		Number	10		5
size		Naira	1,025,687		1,351,309

Household income					
Cassava farming experience Cassava value adding experience		Years Years	19.68 16.81		9.92 9.62
Market distance		Km	3.63		2.22

Table 1. Contd' Socio-economic characteristics of the respondents (Categorical variables used in probit regression)

Variables		Type	Frequency		Percentage
Sex		Male Female	204 21		90.67 9.33
Education		No Formal Formal	35 190		15.56 84.44
Marital Status		Married Single	201 24		89.33 10.67
Land ownership status		Owned Rented	106 119		47.11 52.89
Credit access		Yes No	161 63		71.88 28.13
Membership of cooperative society		Yes No	176 49		78.22 21.78
Access to extension services		Yes No	133 92		59.11 40.89
Access to at least 5 hours electricity/day		Yes No	145 79		64.73 35.27

Source: Field Survey, 2022

Determinants of farmers participation in cassava value addition

The probit regression returned a coefficient of determination of 0.69 implying that 69% of the variation in the dependent variables was explained the variation in independent variables. Five of the variables significantly explained the decision to participate in value adding activities. The coefficient of marital status is significant and negative, indicating that the likelihood of participating in cassava value adding activities is higher among non-married farmers compared to their married counterparts. More experienced farmers were also more likely to participate in cassava value chain (Ao et al., 2019; Apata, 2019). Membership of cooperative society was also found to significantly increase the probability of participating in cassava value chain by the smallholders (Adeyemo, et al., 2019). Also, access to extension services significantly increased the likelihood of participation (Onakuse, et al., 2018). Finally, the number of members of household earning income is significant and positive, implying that the larger the more the number of working household members, the higher the probability of the household participating in cassava value chain.

Table 4.2: Probit regression (Determinants of participation in cassava value adding activities)

Processing Status	Coefficient	Standard Error	Z	P>|z|
Sex	-0.6778	0.4900	-1.38	0.167
Age	-0.0182	0.0267	-0.68	0.494
Marriage	-1.7761***	0.6186	-2.87	0.004
Education	-0.1143	0.1981	-0.58	0.564
Planting Exp	0.0562**	0.0274	2.05	0.040
Household	-0.0926	0.0654	-1.42	0.157
Mem Household Tot Income	0.2173*	0.1292	1.68	0.093
Land owned	0.0324	0.0753	0.43	0.667
Water distance	0.1929	0.1814	1.06	0.288
Credit access	-0.8725	0.5532	-1.58	0.115
Coop association	1.0575*	0.5999	1.76	0.078
Extension	2.8056***	0.5779	4.85	0.000
Training hours	0.0924	0.0614	1.51	0.132
Market distance	0.1874	0.1235	1.52	0.129
Electric time	-0.0367	0.0300	-1.22	0.222
Cons	-0.0691	1.3723	-0.05	0.960

Note: *, ** and *** represent significance at 1%, 5% and 10% respectively.
Source: Field Survey, 2022

CONCLUSION

This study analysed the determinants of the participation of cassava farmers in value addition in Benue State, Nigeria. The factors with positive influence on participation are membership of cooperatives, access to extension services, planting experience and having a large number of income earners in the household, and the only variable with a negative effect is marital status. Policies that will encourage farmers to join cooperative societies and increase farmers' access to extension services are suggested.

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Economic importance of farm house: The perspective of agricultural economics and extension service providers in Kwara state, Nigeria.

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ABSTRACT

Farm house are those structures sited within the farm area to facilitate storage and ease of movement of farm produce on the farm. It supports maximum productivity of plants and animals, enhance the preservation of farm tools and promote favorable environment for farm resources. As such their economic importance cannot be overemphasized. This paper aim to look into the various forms of farm structures set up on the farm such as maize crib, silos, yam barn, processing sites, screen house, tractors or farm machinery house, poultry house, pig house, fish pond, sheep and goat house. The method it applies embraces the cogent roles displayed by agricultural economics and extension service provider in facilitating the establishment of these structures on the farm. It further highlights the challenges encountered in the course of maintaining these structures and proffers appropriate solution. The result comes in the form of providing concrete solutions that will increase the life span of these structures through the various measures outlined, with the synergetic effort of farmers, agricultural economics and extension providers. In conclusion, value of farm produce in rural and urban areas can be effectively enhanced and sustained over-time, pest infestation and wastage can be successfully reduced to the minimal. Also, plant and animal growth can be technically managed by farmers through the assistance of extension personnel with credited expertise for increased farm productivity and farmers' profitability.

Keywords: Farm house, Economic importance, Agricultural Economics, Extension, Service providers.

INTRODUCTION

Definition of farm house

Farm house vividly describes the siting of buildings on the farm in order to be able to carry out specific farm operations and activities without any stress. They often come with specific purpose attached to their establishment on the farm. This often relate to the various farm enterprises that farmers often engaged in within the farm premises, which subsequently necessitates the establishment of these structures on the farm. This often facilitates optimum plant growth, plant and livestock management, excellent storage system, processing, packaging and marketing of farm produce. Without the establishment of these structures on the farm, it could limit the rate at which each of the various activities carried out on the farm could be well managed, thereby leading to a lot of production deficiencies on the farmers' part. Several studies related to this study has either worked on single unit of farm structure on the farm stead, some on storage and feeding system and many others worked on intricate details in constructing these structures on the farm. This paper tends to bring in a new dimension by emphasizing the role played by agricultural economics and extension personnel in the establishment of these farm structures. Previous studies reviewed by Blakely, Aviagen, Simpson, Campbell and Macklin (2007) studied the economic importance of poultry house and ventilation management, also Mississippi State University Extension, (2018) also worked on feedstuff handling, storage and feeding system for livestock. Moreover, Ojedele, Ezejiofor, Ehiomogue and Orji (2018) investigated the necessity of farm structures in Nigeria. However, there is need to ascertain the economic importance of these farm structures in relation to the perspective of agricultural economics and extension service providers, in order to minimize loss, wastage of farm produce, improve plant and livestock management, maximize profit in agricultural production as well as promoting value additions to these produce on the farm.

Economic Importance of these structures to the farmers

Establishment of farm buildings or structures comes with great economic value to the farmers in diverse forms. Starting with the construction of the maize cribs, it helps the farmers to prevent unnecessary wastage and spoilage of their unsold or leftover maize at the farm gate. The left over maize are preserved from rot and infection by storing them in the cribs. It also provides increment in the shelf life of the crop due to the efficient storage system along with the provision of adequate aeration of the maize crops within the crib (Manandhar, Milindi, and Shah, 2018). The use of silos poses an advantage in prolonging the shelf life of variety of grains stored inside them. The preservative environment within the structures is usually prepared by farm workers, which helps in warding off susceptible insects, weevils, rodents, as well as regulating the moisture content of these grains over a long period of time. Certain factors such as moisture content, relative humidity, temperature and oxygen are carefully controlled by these service providers (Manandhar, Milindi and Shah, 2018). Grain contaminations through microbial or fungi infestation during storage are also eliminated during this period. The quality of grains would have been enhanced and as such tend to attract a higher purchasing power from the consumers.

Moreover, when these grains are scarce in the market, the economic advantage is much more pronounced for higher sales as consumers demand rises to have these grains at all cost. This will inadvertently improve the standard of living of the farmers whenever the grains are needed for commercial purposes either on a large-sale or small-scale (Ojedele, Ejiofor, Ehiomogue and Orji, 2018). The economic advantage of using barns tend to be well pronounced during marketing, as reduction in transportation cost based on the number of tubers being transported to the market are minimized. This comes into play when excess tubers are carefully stored in the barns; these help farmers in preserving those tubers for the next cropping season as well as reduce the proportion of tubers that would have been damaged in the process of sorting, grading and packaging during marketing (Umogbai, 2013). Farm processing buildings helps in reducing the stress of conveying farm produce to processing centers outside the farming premises. Hence it promotes proper coordination of women processors who are able to mobilize themselves for optimum productivity of those farm products with better processing and packaging skills (Manandhar, Milindi and Shah, 2018).

Roles played by Agricultural Economics and Extension Service Providers in the use of these structures

- First and foremost before the establishment of any structure on the farm, there is need to engage in rigorous planning. This entails getting specific details of areas to be mapped out during construction, the size of the enterprise the farmer is involved in i.e. whether it's a crop or livestock, small or large scale; which could determine how small or big the farm structures will be in the long run. Agricultural economics provider has a major work to play by intimating the farmer on the pros and cons of siting the structures on distinct areas of the farm. For instance, considering the topography of the farm land, checking the master plan of the farmland, the type of soils present within proposed farm area and the distance where farm structures should be to the cultivation site will juxtapose the credibility of choosing such areas for farm use. The extension provider also guides the farmer to where he can purchase those tools or machineries at affordable prices as well as making sure they are of good quality to ensure durability of these tools (DLEC, 2019).
- Establishment of farm structures is very relevant to both agricultural economics providers as well as agricultural extension providers. Both practitioners influences the way these structures are functional and well managed on the farm on a consistent basis (FAO, 2020). They practically guide the farmers on making optimum use of these structures through thorough managerial procedures, regular check- up, daily maintenance before every farm operations and harvesting period. In relation to the Agricultural Economics providers, they equally help in supervisory roles with the assistance of farm managers.
- Farm managers and extension agents' offers practical advice to farmers by assisting farmers in taking sound decisions regarding current and up to date structures that will be very relevant to their various enterprises (FAO, 2016). This consequently have a way of improving the productivity of such farmers, especially those farmers that are embarking on going on a larger scale in their farming business.
- Farm managers and extension providers also engage in educative roles by educating and training the farmers on the benefits derived in having adequate and functional structures on the farm. These structures could also have further sub-structures where different home products can be produced. For example, siting of oil-palm processing center on the farm can further lead to production of soaps, detergents, palm oil, shea butter, body creams, etc. This could contribute to the farmers' entrepreneurial capacity by diversifying into other farm preservative skills (DLEC, 2017). One good thing this creates for the farmers is the provision of other reliable coping strategies that they can easily fall on during off-season or non-farm activity periods.

Challenges encountered in the course of establishing and maintaining these structures

- Part of deficiencies that could be experienced during production if these farm structures are not in place include: physical loss such as glut of farm produce like eggs, spoilage of grains, wastage of fruits, theft, loss of energy, fatigue and experiencing unnecessary financial stress in the transportation of these produce. All of these challenges poses a great threat to the health of the farmers (FAO, 2016).
- Also the challenge of inadequate land allocation or land space in constructing a durable structure also poses a threat to the farmers. Farmers that are struggling to buy more land

in expanding their farming business might find it very difficult in ensuring standard structures for each of the various enterprises they are engaged with on the farm due to poor access to funds (FMARD, 2020).

- There is also the issue of post- harvest losses which originates from poor construction of farm structures which could affect the crops that are stored in the storage facilities or houses. This has the tendency of facilitating deterioration easily, if adequate care and proper farm building recommendations are not taken into consideration when siting these structures. The crops might be at the risk of microbial infestation such as fungus, microbes, mold etc. This usually comes up as a result of not fumigating the grains, crops or farm structures very well before storage. It could also be as a result of dampness or high moisture content in the storage houses. Most post-harvest losses encountered by farmers are usually caused by inadequate post-harvest management practices (FAO, 2020).
- Another issue that could be encountered on the farm is rodents and pest attack during storage. These include grain borer, moths, beetles, weevils, etc. All of these are facilitated through other physical conditions that are not well managed. These include openings or cracks along the farm structures like the roof, walls or floors. Other factors that could influence these also are unstable room temperature; moisture level of the materials used in constructing these farm structures such as wood, asbestos, used aluminium foils as well as crop grains stored within the storage facilities. All of these can trigger the multiplication of these pests and insects within a short period of time thereby causing irreparable damage to the grains and farm structures (FMARD, 2020).
- Another factor that can affect building of farm structures is inability to contract farm building experts who are competent in establishing these structures for small-holder farmers. For instance, a farmer who barely has a two acre of land for his arable crops would be the last person to consider establishing standard farm structures on his farm based on low farm space and poor financial capacity in setting up these structures on his farm (Ruwaichi and Werema, 2018).

SOLUTIONS TO ENSURING ELONGATION OF LIFE SPAN OF FARM STRUCTURES

a. Farmers can receive mutual support from other farmers by soliciting for help from others in siting farm structures on their farms and also making sure the same help is rendered back to farmers' that gives them a helping hand. This way unnecessary spending can be reduced by getting extra hands to assist in farm labor in the siting of farm structures. This emphasizes cooperative support among farmer groups by forming viable farmer cooperatives based on the various enterprise engaged by the farmers in rendering both physical and financial aid.

b. Economics and extension providers should ensure that farmers have access to good farming materials by advising and encouraging them on the benefits of using durable materials for the farm structures to be sited on their farms. This will help them to have minimal loss and rodent attack as regard the produce stored in these structures (FAO, 2020).

c. Economics and extension providers should also link the farmers with viable credit institutions where they can have access to credits, loans in order to equip their farms with current and relevant farm structures. Institutions like micro finance banks, agro-allied banks and non-governmental organizations will be relevant in accessing adequate funds for the farmers' need of standard structures on the farm. This is mainly due to the fact that these specific aforementioned financial institutions specially have genuine interest in developing grass-root farmers, so that their standard of living and productivity on the farm can be enhanced (Ruwaichi and Werema, 2018).

d. Economics and extension providers can also ensure that environmental conditions are well monitored and properly controlled. For instance, in the case of siting of screen house, one will have to ensure that optimum flow of air, sunlight, water and humidity is carefully monitored and maintained all through the growing period of the crops (Kittas, Katsoulas, Rigakis, Bartzanas and Kitta, 2012). This will increase the quality of the crops produced under this stable environment. The same applies to other structures like silos, livestock structures and machinery structures on the farm. It will prevent spread of diseases, erosion of farm implements as well as pollution of farm produce (DLEC, 2019).

CONCLUSION AND RECOMMENDATION

The establishment of farm structures on the farm is very vital for the farmers' economic virility and feasibility as regard agricultural production all through the farming season and beyond. It helps in building cohesive units for marketing, storage and processing of the farm produce harvested. The role of agricultural economics and extension service providers over the siting of these structures vary from giving practical advice, educating farmers, planning on how to establish these structures, monitoring and supervising how they can utilize these structures effectively for the development of their farming business. These service providers are also capable of giving hands on learning on how to operate and maintain the structures over a long period of time by using durable materials. They can also help in the provision of necessary farm supplies or services such as source of labor from other farmers within the farming settlements. Challenges encountered while using these structures can be effectively monitored and curbed by the relevant and current information received on the sustainability of these structures through the advice and training given by these service providers. It is therefore recommended that government should work hand in hand with these agricultural service providers in order for the latter to have a sustainable impact by ensuring the establishment of viable structures on farmers' farm. They can also help in linking farmers up to agricultural financially based institution so that they can have access to credits. They can also do well in advising the farmers on how to procure durable farm materials and structures that can boost the farmers' standard of living and farming conditions.

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EFFECT OF CLIMATE CHANGE ON CATFISH FARMING HOUSEHOLDS' WELFARE IN OGUN STATE, NIGERIA

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ABSTRACT

The study investigated the effect of climate change on catfish households' welfare in Ogun state. Data were collected with the aid of structured questionnaire to elicit information from 80 catfish farmers in the riverine communities of Odogbolu LGAs that were selected through a multistage random sampling technique. Data were analyzed using descriptive statistics and inferential statistics. The average age, education and fishing experience of the respondents were 43.5 years, 13.8 years and 12.6 years respectively. Perception of climate change attributes showed that 65%, 97.5%, 87.5% and 76.5% of the catfish farmers have observed increased temperature, rainfall, changes in timing of rains and stronger winds. Similarly, 85% of the fishers have experienced flooding in their farms. Ordinary Least Square result showed that education, experience, extension contacts, household size, experienced losses due to flooding and proportion of income loss due to flooding were the relevant and significantly determined catfish households' welfare. Policies attention should be provision of early warning signal through extension agents, improving adult literacy programme among the fishing communities to help mitigate the adverse effect of climate change.

Keyword: Climate change, Catfish farmer, Flooding, Households' welfare

INTRODUCTION

Climate change as defined by United Nation Framework Convention on Climate Change (UNFCC) refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The growing evidence from the Intergovernmental Panel on Climate Change (IPCC, 2007; Mikhaylov et al. 2020) that climate will change as greenhouse gases accumulate has added urgency to the need to understand the consequences of global warming. Initial studies of climate change, using a variety of methods, identified Africa as one of the most vulnerable locations on the planet to climate change because it is already hot and dry, a large fraction of the economy is tied to agriculture, and the farming methods are relatively primitive (Mendelsohn and Williams 2004). Climate change creates uncertainty in the rainfall pattern (timing and amount) and affects agricultural activities. Over 60% of the Nigerian populace depends so much on agriculturally related activities for sustenance. Agba *et al*. (2017) opined that climatic fluctuation is putting Nigeria's agriculture system under serious threat and stress. This implies that rural sustenance and food security in Nigeria is under serious threat. Current environmental problems in the coastal area of the country are flooding which comes from the high rainfall, run off from rivers and urban chains and tidal movement and wind (Echendu, 2020). There is glaring evidence that climate change is not only happening but it is changing our lives.

As a result of flooding, some species of fishes have migrated to another location while some others died. This leads to low productivity and consequently reduced fish catch and low standard of living. The consequences of flood due to climate change such as loss of fish, change in fish species, erosion of human habitat, and land will have greater impact on the welfare and the livelihood of fishers most especially in terms of income realized from fishing activities.

MATERIALS AND METHODS

The study area was carried out in Ogun state, Nigeria. The state has a natural vegetation that is broadly of two types: the forest and the savannah vegetation which are almost evenly distributed throughout the zone. The climate in the state is characterized by a generally high but uniform temperature, a high relative humidity and a marked rainy season. The State is divided into four Agricultural Development Programme zones (namely the Egba, Ijebu, Remo and Yewa zones) by the Ogun State Agricultural Development Programme (OGADEP) Authorities. The state has 20 local government areas. A multistage sampling techniques was employed for the study. Ijebu Ode zone was purposively selected from the four zones of the Ogun State Agricultural Development Programme (OGADEP) this is because of large concentration of catfish farmers along the riverine communities of this zone. In stage two, Odogbolu local government area was purposively selected based on the records of catfish farmers obtained from the village extension officer covering the areas. In third stage, three riverine communities where catfish rearing activities was prevalent (Eriwe farm, Iwata and Ikangba) were purposively selected from the local government area. Finally, eighty catfish producers along the river banks of these communities were randomly selected in a proportionate sampling method. The study was conducted between June-November, 2021 after the floods that ravaged these communities in that year.

Primary data were collected from catfish producers through the aid of well-structured questionnaire. The questionnaire covered the socio-economic characteristics of the catfish famers, climatic variables, flooding experience etc Descriptive statistics that was employed for analysis include: frequency, percentages, mean, and standard deviation were used to analyze the socio- economic variables of the respondents, climate variables (rainfall, temperature, wind), flooding experience and proportion of loss income due to flooding) Also, Inferential statistics were used to estimate the relationship between the household welfare using an ordinary least square (OLS) regression estimation. The dependent variable used to capture household welfare is per capita expenditure. Expenditure on food and non-food items were aggregated for each household and divided by household size to obtain the per capita expenditure for each household. Per capita expenditure is used as proxy for per capita income and employed as a measure of welfare.

Model specification

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, \dots\dots\dots\dots\dots..X_{11}) \ldots\ldots\ldots\ldots(1)$$

Y = Log of per capita expenditure (Total household expenditure/ household size), X_1 = Gender (1 =male, 0 = otherwise), X_2 =Age of fishers in years, X_3 = Education in years, X_4 = Household size, X_5= Fishing experience (years), X_6 = Dependency ratio (Non-working households / working households), X_7 = Membership of Association (1= belong to an association, 0 = otherwise), X_8 = Access to credit (1 = have access, 0 = otherwise), X_9 = Extension contact (Number of visit),X_{10} = Experience loss due to flooding (1=Yes, 0 = otherwise), X_{11} = Proportion of loss due to flooding (% of loss of income from fishing activities due to flooding).

RESULTS AND DISCUSSIONS

Table 1 presents the socioeconomic characteristics of catfish farmers in the study area. The result shows that the mean age of the catfish farmer was 43.5 years, this indicates that catfish production in the study area were dominated by those in their adulthood age. Hence, they would be able to withstand and manage the risk associated with adverse weather effect in production. The average fishing experience was 12.6 years. This implies that with the level of experience of the sampled farmers they are expected to have more knowledge and information about climate change and agronomic practices that they can use in response to climate change. The mean household size was 8 persons. This implies that other members of the household can provide labour in catfish production thus limiting their dependence on hired labour and saved cost.

Table 2: Socioeconomic characteristics of smallholder maize farmers (n=80)

Variable	Mean	SD
Age (years)	43.5	9.15
Fishing experience (years)	13.6	8.82
Household size(number)	8	1.23

Source: Field survey, 2018

Table 2 shows the climatic change experienced by catfish farmers in the study area. Result shows that 65% of the catfish farmers experienced increased temperature while 16.5% of the respondents said they experienced decreased temperature Almost all the respondents (97.5%) claimed to have experienced increased rainfall which cause serious flooding along the river banks during the year under review. Contrarily, none of the catfish farmers experienced decreased rainfall during the year under study. However, about 87.5 % of the fishers claimed to have experienced changes in the timing of rains. This, according to the fishers caught them unawares thus cannot be able to predict the time of rains with certainty. Also, 76.3% of the catfish farmers have experienced stronger winds that led to heavy storm that destroyed most of the barricades built to fenced the ponds as a coping mechanism against floods hence resulted to loss of catfish during the flooding period. Catfish farmers' flooding experience revealed that 85% of them experienced flooding during the year under study while 15% of the sampled respondents claimed not to have experienced flooding during same period. Proportion of loss during flooding indicates that 32.4% of the fishers lost 75% of their income during the period, 58.8% of those that experienced flooding during the period claimed to have lost 50% of their income and 11.8% of the catfish producers lost 25% of their income as a result of the flooding during the year under study. This lost is attributed to significant quantity of fish that was wiped away by the flooding that occurred between June-November, 2021 which corresponds to the peak period of raining season.

Table 2. Experience of catfish producers with Climate change characteristics (June-November, 2021)

Climate change experience	Frequency	Percentage
Increased temperature	52	65
Decreased temperature	45	56.5
Increased rainfall	78	97.5
Decreased rainfall	-	-
Change in timing of rains	70	87.5
High winds	61	76.3
Flooding experience		
Experienced loss	68	85
No loss was experience	12	15
Proportion of loss Due to flooding		
75 percent	22	32.4
50 percent	40	58.8
25 percent	8	11.8

Source: Field survey, 2021 Note: Multiple response

Table 3 presents the result of Ordinary least square estimate of the determinants of catfish farmers' household welfare. The co-efficient of determination (R^2) was 0.658. This implies that 65.8% variations in household welfare are explained by the explanatory variables included in the model. The adjusted R^2 (0.589) suggested that the model was not over-fitted. The F-statistics (8.582, $p<0.01$) indicates that the overall model is significant at 1% and Durbin Watson of 1.576 shows the absence of autocorrelation. Result show that the coefficient of education, fishing experience, extension contacts have a positive and significant relationship with households' welfare while the coefficient of household size, experienced loss due to flooding and proportion of income loss due to flooding have a negative and significant relationship with household welfare in the study area. Increase in the year of education and years of fishing experience by 1% will increase household welfare by 16.1% and 19.1% respectively. This implies that an educated catfish farmer possessed the ability to adopt new and improved technologies to mitigate the adverse effect of climate change and ability to better optimize on fish farming practices. Similarly, the accumulated years of experience may enable them to evolve the fishing practices that are most suitable to their environment which may impact positively on the household welfare. Also, receiving extension services has the positive impact on fishers' household welfare. Result further revealed that household size, experience loss due to flooding and proportion of loss due to flooding has negative coefficients and significant at 1% probability level respectively. This implies that increase in these variables will reduce household welfare by 3.2%, 15.6% and 42.1% respectively. By implication, this study shows that flooding affects the welfare of catfish farmers negatively. This result corroborated the findings Ajibade et al., (2015) and Udemezue et al., (2019) who in their respective studies reported that flooding resulted in significant economic losses to farmers.

Regression result of factors determining Catfish farmer's households' welfare

Variables	Co-efficient	Standard error	T-value
Gender	-0.012	0.016	0.751
Age	0.251	0.185	1.356
Education	0.161***	0.043	3.744
Household size	-0.032**	0.013	-2.462
Fishing experience	0.191**	0.078	2.448
Dependency ratio	-0.091	0.115	-0.791

Membership of association	0.212	0.346	0.612
Access to credit	0.312	0.255	1.223
Extension contacts	0.128*	0.075	1.706
Experience loss due to flooding	-0.156***	0.028	-5.571
Proportion of loss due to flooding	-0.421***	0.132	-3.189
Constant	4.821***	1.296	3.719
R^2	0.658		
Adj R^2	0.589		
F-ratio	8.582***		
Durbin Watson	1.576		

Source: Field survey, 2021

Legend: ***significant at 1%, **Significant at 5%, *Significant at 10%

CONCLUSION AND RECOMMENDATIONS

The study revealed that catfish farmers in the study area have experienced adverse effect of climate change attributes of which the most prevalent is the flooding that resulted from increased rainfall that ravaged the communities in the year under study. About 85% of the catfish farmers experienced a loss in income as a result of flooding. Ordinary Least Square result showed that education, experience, extension contacts, household size, experience loss due to flooding and proportion of income loss due to flooding were the relevant and significant variables that determined catfish households' welfare. Policies focus should be the need for early warnings signal by Nigerian meteorological agency through the extension agents to fishing communities to enable them make informed decisions and allow them to better prepare for adverse weather conditions, improvement of adult literacy programme as this will increase fishers' knowledge and help them appreciate the benefits of adapting to climate change.

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Determinants of agricultural credit acquisition among arable crop farmers in Ogun State, Nigeria

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ABSTRACT

The study examined the influence of cooperative credit use on arable crops production in Yewa Division of Ogun State, Nigeria. Primary data were collected through a multistage process from 79 (38 cooperative and 41 non-cooperative) arable crop farmers in the study area. Data were analysed using descriptive and Logit regression. The findings revealed that cooperative credit is considered as the basic ingredient for each and every economic activity including agriculture. Results of the analysis showed that the probability of accessibility to credit and farm productivity was highest for farm size (0.795) and least for farm input (-0.826) implying that increasing farm size to access credit was the most desirable. Also, in the same category is the co-efficient of variable regular payment of monthly dues (X_1) which is significant at 1% level. This has a direct bearing on policy formulation that farm size and regular payment of monthly cooperative dues are required as criteria for accessibility of cooperative credit. The study concludes that credit acquisition by the farmers is mainly determined by gender, farm income, farm inputs and experience. The study recommends policy formulation that improves allocation of more farmland for arable farming and encouragement of gender equality in arable crop production.

Key words: *Arable crop production, agricultural credit*

INTRODUCTION

Credit accessibility is a crucial factor in the development of the agricultural sector. Agricultural producers rely on credit facilities to raise the capital required to initiate and sustain production activities. The role of credit in agricultural production is crucial because inputs such as seeds and fertilisers are purchased at the beginning of the production season, but returns are realised only at the end of the season (Masuku, 2009). Credit availability to agriculture is particularly justified when farmers have very low savings capacity, poorly developed rural financial markets and availability of appropriate farm technologies whose adoption is constrained by shortage of funds. These conditions hold in Nigerian agriculture.

Muhammad, Munir, Kalbe (2003) opined that agricultural growth depends on increased use of agricultural inputs, technological change and technical efficiency. The optimal use of inputs requires funds at the disposal of farmers. In less developed countries like Nigeria where savings are negligible especially among the smallholder farmers, agricultural credit becomes an essential input along with modern technology for higher productivity.
In this realisation, Nigerian governments, supported by multi- lateral and bi-lateral aid agencies, have devoted considerable financial resources to supplying cheap credit facilities to the farmers and other rural entrepreneurs in a myriad of institutional settings (Nwaru, 2004). Unfortunately, these rural credit structures have not been able to achieve the desired aim of effectively and efficiently facilitating the inflow of financial services into the rural economy to enable rural entrepreneurs, including the farmers to employ efficient production techniques designed to raise their physical output and incomes (Nwaru, 2004).

PROBLEM STATEMENT

The population expansion together with a poor distribution of food is among the world's greatest problem today. In Nigeria, production of food has not increased at a rate that can meet the increasing population. In developed countries, growth of population in relation to farm output is rather stable but in a developing country like Nigeria, there is no compensation for population increase by the total farm output. The arable crop production is not playing the role of effectively supplementing the food content in the average consumer's diet in Nigeria. These problems centre on inadequate finance which leads to low production and many still use traditional method of crop production. Other problems include high cost of input, diseases and marketing problems. This situation has forced many small scale farmers to close down and those still managing to survive are producing at very low with serious inputs' limitations. Capital is needed to modernize agriculture because new technologies have to be purchased before they can be used on the farms. In spite of the serious need for capital, the amount of it available to most farmers is a quantum compared to the alternative uses for the capital. Inadequate capital stems from small – scale of operations of most farmers as a result of which they have little surplus to generate income. This study thus sets to examine the determinants of agricultural credit on arable crops production.

METHODOLOGY

The Study Area

The study was carried out in Yewa division of Ogun State, Nigeria. Yewa division has five Local Government Areas. The division is bounded to the West by the Republic of Benin with which it shares a long stretch of international boundary. It is bounded in the East by Oyo State, Abeokuta-North, Ifo Local Government Areas and in the South by Lagos State. The climatic condition and physical environment have been generally supportive to farming as reflected in the variety and quantity of cash and arable crops grown in the area.

Sampling Technique

The data for the study were essentially from primary source with the use of structured questionnaire in a multistage process. In the first stage, two (2) Local Government Areas were chosen randomly out of the five Local Government Areas in the Yewa Division. The second stage involved the selection of five (5) towns from the two Local Government Areas selected. The third stage involved the selection of five (5) cooperative and six (6) non-cooperative arable crop producers from each of the town selected in stage two, but data from 79 respondents (38 cooperative and 41 non-cooperative arable crop producers) were used for the study.

Methods of Data Analysis

The data collected were subjected to descriptive analysis and Logit.

Descriptive Statistics

The socioeconomic features of the arable crop farmers were statistically described using mean, frequency distribution, and percentage.

Logit Regression Model

For the logit model, it is assumed that an individual is faced with two alternatives, arable crop farmers acquire credit from the Cooperative Credit Societies or not. Therefore, logit model was employed to determine the characteristics that influence the probability that enables arable crop farmers to acquire credit. The logit regression model is characterized by binary dependent variables with mutually exclusive outcomes. The dependent variable is the credit status of the respondents which is one (1) if he/she obtain credit and zero (0) if otherwise. Since the dependent variable is ordinal in nature, a variant of the ordered probit, and an ordinal logit model (Zavoina and McElvey, 1975), was used to analyse the dichotomous access to credit.

For the ordinal logit model we let,

$$Y_i^* = \beta^! x_i + \varepsilon_i \qquad (1)$$

Where Y_i^* is the underlying latent variable that indexes the credit access that arable crop farmer experience, x_i is a vector of explanatory variables, β is a column vector of parameters to be estimated and ε_i is the stochastic error term. The probability for each observed ordinal response, which in this case are only of two categories (1,0) for credit access, no credit access is given as;

$$P(Y=1) = P(Y^* \leq 1) = P(\beta' x_i + \varepsilon_i \leq 1) = F(-\beta' x_i)$$

$$P(Y=0) = F(\delta_0 - \beta' x) - F(-\beta' x) \qquad (2)$$

$$Y_i = \alpha + \beta_{i1}X_1 \ldots\ldots\ldots\ldots\ldots\ldots + \beta_{i1}X_{18} + \varepsilon_i \qquad (3)$$

Where:

Y_i = (= 1 if the arable crop farmer is a credit beneficiary, 0 = non beneficiary)

The explanatory variables are:

X_{1i} = Regular payment of monthly dues (Yes = 1, No = 0)
X_{2i} = Age of the household heads (years.)
X_{3i} = Gender (Male =1, Female = 0)
X_{4i} = Credit experience (years)
X_{5i} = Loan default (%)
X_{6i} = Interest rate (%)
X_{7i} = Number of loan applicants received (number)
X_{8i} = Income (₦)
X_{9i} = Farming experience (years)
X_{10i} = Farm size (hectares)
X_{11i} = Household size (number)
X_{12i} = Educational attainment of the household head years spent in formal school
X_{13} = Labour cost (₦)
X_{14i} = Farm input (₦)

RESULTS AND DISCUSSION

Socio – Economic Characteristics of Arable Crop Farmers

The summary of the socio-economic characteristics of arable crop farmers is presented in Table 1. The variables discussed include age, farm size, farm experience among others. Majority (31.5%) of cooperative arable crop farmers had farming income within ₦300.001 – ₦400,000 compare to their non-cooperative counterpart that majority (58.6%) had farming income within ₦100.001 – ₦200,000. This implies that cooperative farmers had higher income due to credit availability to their farm production compare to their non-cooperative counterparts that had lower income. Majority (39.6%) of the cooperative farmers has farm experience within 31 – 40 years while majority (36.8%) of the non-cooperative farmers had farming experience of less than equal 20 years, it corroborated with the findings of (Olarinde *et al* 2004) who stated that farming, like any other business, also require experience and management skill, which are associated with age.

Table 1: Distribution of socioeconomic of Arable Crop Farmers

Variables	Cooperative Credit Beneficiaries		Non – Cooperative Credit Beneficiaries		Pooled Data	
Age Group (Years)	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Less than 30	5	13.2	9	21.9	14	17.7
31 - 40	8	21.1	11	26.8	19	24.1
41 – 50	10	26.3	8	19.5	18	22.7
51 – 60	12	31.6	10	24.3	22	27.8
Above 60	3	7.8	3	7.5	6	7.7
Total	38	100	41	100	79	100
Mean	45		40			
Standard deviation	9.83					
Farming Income (₦)						
≤ 100,000	5	13.2	10	24.4	15	19
100,001 – 200,000	5	13.2	24	58.6	29	36.7
200,001 – 300,000	5	13.2	5	12.2	10	12.7
300,001 – 400,000	12	31.5	1	2.4	13	16.4
400,001 – 500,000	5	13.2	1	2.4	6	7.6
Above 500,000	6	15.7	-	-	6	7.6
Total	38	100	41	100	79	100
Mean	₦344,512		₦156,097			
Gender (Sex)						
Male	31	81.6	27	65.8	58	73.4
Female	7	18.4	14	34.2	21	26.6
Total	38	100	41	100	79	100
Farm Experience (Years)	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
≤ 20	4	10.5	15	36.6	19	24.0
21 – 25	2	5.3	10	24.4	12	15.2
26 – 30	5	13.2	11	26.8	16	20.3
31 – 40	15	39.6	5	12.2	20	25.3
Above 40	12	31.4	-	-	12	15.2
Total	38	100	41	100	79	100
Mean	31		24			
Farm Size (Hectare)						
01 – 2.0	9	23.7	20	48.8	29	36.7
2.01 – 4.0	11	29.0	11	26.8	22	27.8
4.01 – 6.0	14	36.8	10	24.4	24	30.4
6.01 – 8.0	3	7.9	-	-	3	3.8
8.01 – 10.0	1	2.6	-	-	1	1.3
Total	38	100	41	100	79	100
Mean	3.7		2			

Source: Author's Computation

Determinant of Cooperative Credit Acquisition among Arable Crop Farmers

The Logit regression model was used to determine the factor enhance arable credit accessibility. The findings shows that six (6) variables among fourteen (14) regressed have significant influence on the arable crop farmers access to credit. The chi - square (σ^2) value was 73.760, with a p – value of less than 0.01 and log likelihood function – 98.038. Hence, sigma square was statistically significant, thus indicating that the model displays a good fit. The variables that had significant co-efficient are regular payment of monthly dues (X_1), gender (X_3), income (X_8), experience (X_9) and farm input (X_{14}). It should be noted that a positive sign on a parameter indicated that higher values of the variables tend to increase the likelihood of credit accessibility and impact on agricultural productivity. Similarly, a negative value of a co-efficient implied that higher values of the variables would reduce the probability of credit accessibility and impact on the farm productivity.

The probability of accessibility to credit and farm productivity was highest for farm size (0.795) and least for farm input (-0.826) implying that increasing farm size to access credit was the most desirable. Also, in the same category is the co-efficient of variable regular payment of monthly dues (X_1) which is significant at 1% level. This had a direct bearing on policy formulation that farm size and regular payment of monthly cooperative dues are required as criteria for accessibility of cooperative credit. Hence, payment of dues should attract topmost importance on the priority list of cooperative members.

Table 2: Logit Model Explaining the Determinants of Cooperative Credit Acquisition of Arable Crop Farmers

Variables	Maximum Probability Coefficients	Standard Error	Marginal Effects
Constant	**1.217 (2.148)**	**0.567**	**-0.915**
Regular Monthly dues(X_1)	**0.167 (3.018) *****	**0.554**	**-0.157**
Age(X_2)	**-0.216 (-0.893)**	**0.242**	**-0.925**
Gender(X_3)	**-0.201 (-2.139) ****	**0.939**	**0.242**
Credit Experience (X_4)	**0.622 (0.560)**	**0.679**	**0.172**
Loan Default(X_5)	**0.661 (0.973)**	**0.679**	**-0.454**
Interest Rate (%)(X_6)	**0.373 (0.549)**	**0.664**	**-0.928**
Loan Applicants (X_7)	**-0.826 (-1.245)**	**0.945**	**-0.538**
Income (X_8)	**-0.232 (-2.451) *****	**0.219**	**-0.477**
Farm Experience (X_9)	**-0.130 (-5.967) *****	**0.217**	**-0.178**
Farm Size (X_{10})	**0.795 (3.663)**	**0.116**	**0.687**
Household Size (X_{11})	**-0.415 (-1.816)**	**0.539**	**0.671**
Education (X_{12})	**0.101 (0.187)**	**0.972**	**0.222**
Labour (X_{13})	**0.299 (0.302)**	**0.686**	**-0.106**
Farm Input (X_{14})	**-0.101 (-0.017)*****	**0.602**	**0.310**
Chi – square value (σ2) = 73.760* , P < 0.01 (significant at 1%) , Log likelihood Value = -98.038**			

Source: Author's Computation

***** Significant at 1%; **Significant at 5%; * Significant at 1%; t – value are in parenthesis**

CONCLUSION AND RECOMMENDATION

The mean age of the respondents was about 45 years and 40 years respectively. This implies both farmers are in their active and productive age, this result also revealed that Cooperative credit beneficiaries farmers are in their active age and can perform better. The probability of accessibility to credit and farm productivity was highest for farm size (0.795) and least for farm input (-0.826) implying that increasing farm size to access credit was the most desirable. In addition the study indicated that the credit acquired by the respondents had significant effects on their output and income. The study concludes that credit acquisition by the farmers had a significant effect on the producitivity of arable crop. Recommend that the farmers should be adequately motivated with needed credit facilities so as to enhance their agricultural production.

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Impact of extension agents training programme on farmers productivity in Delta North and South agricultural zone, Delta State, Nigeria.

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ABSTRACT

This study investigated the impact of extension agents training programme on farmers productivity in Delta North and South agricultural zone, Delta State, Nigeria. It described the socio-economic characteristics of the farmers trained extension agents in Delta State, determined the level of productivity of the extension agents trained farmers, determined the level of satisfaction of training received by the farmers and ascertain the derived benefits obtained from the training received. A sample size of 111 was used for the study and it was obtained through multi-stage sampling technique. Descriptive statistics and inferential statistics was respectively used to analyze the objectives and hypothesis of the study. Results revealed that respondents mean age, household size, farm size, farm experience and farm income was 45.27 years, 6 persons, 2.75 ha. 10.26 years and ₦328,378.38 respectively. Majority (87.39%) of the respondents were satisfied with the extension agents training programme due to benefits obtained from the training programme. Based on results women should be encouraged to participate in training programmes since they are known as stake holders in where farming is concerned.

Keywords: *Training, farmers, extension agents, benefits, programme, satisfaction.*

INTRODUCTION

Farming activities carried out by farmers require so much of training especially if good and sustainable results on productivity on farmers level of output are expected Onuka (2012). Training helps to guide against accidents and wastage of farm resources. Buttressing further, Salihu (2011) stated that level of training is directly in line with level of productivity. Against this background, Salihu (2011) advocated the need for steady manpower training as it helps as an instrument for effective achievement of organizational objectives and goals that is likely to result to greater farm productivity and consequently income. Farmers training is carried out by the extension agents functioning in agricultural institutions (Erie, 2009). Erie (2009) opined that the basic reason why extension agents train farmers is to equip them with the skill and procedures that would help improve farming methods techniques and as well increase production efficiency, income and better standard of living. This study therefore examines the impact of training received by farmers on their farm productivity.

Specifically, the study describes the socio-economic characteristics of the farmers trained by the extension agents in Delta State, determine the level of productivity of the extension agents trained farmers in the area, determine level of satisfaction of training received by the farmers and ascertain the derived benefits obtained from the training received by the farmers in the Delta State.

Hypothesis of the Study: There is no significant difference between the proportion of farmers satisfied and those not satisfied from the training received from the extension agents.

MATERIALS AND METHODS

The study was carried out in Delta State. Delta State is made up of three agricultural zone (Delta North, Delta South and Delta Central, with 25 local government areas (LGAs) and the capital is Asaba. It is made up of a population size of 5,475,139 (NPC, 2016). It is also known to have many towns like Asaba, Sapele, Agbor, Ughelli, and Warri which is known as the economic nerve centre of the state (NAEC, 2008). Delta State has a size of 17,698Km^2 and so ranks 23rd amongst other states in the country (Delta State, Wikipedia). The people engage in different occupation like farming, oil prospecting, and civil service among others.

The study was carried out in Delta State and it adopted a multi-stage sampling technique. Stage 1 started with a random selection of Delta North and Delta South agricultural zones. This is followed by the random selection of 2 LGAs per agricultural zone, thus making them 4 LGAs that were used for the study. Three (3) communities / towns were then randomly selected per LGA, thereby resulting the communities / towns to 12. The final stage involved a random selection of 10 farmers out of about 15 of them being trained by the extension agents per community / town, thus making the total number of farmers contacted for the study to 120. The researcher ensured that the selected farmers are those served by the extension agent of the area. They were served with the question instrument and from those returned, one hundred and eleven (111) (92.5%) which were suitable for analysis were selected and used for the study.

Descriptive statistics involved the use of frequency tables, percentages and means and they were used to analyze the objectives of the study. On the other hand, inferential statistics (Binomial test) was used to analyze the study's hypothesis. A four-point Likert scale was used to analyze the derived benefits from training by farmers The scale ranges from, Strongly Agree: (coded 4), Agree: (coded 3), Disagree: (coded 2) and Strongly Disagree: (coded 1). The weighted mean score of 2.50 (obtained as: 4 + 3 + 2 + 1) / 4 = 2.50) and above was agreed as derived benefits by the farmers from training received.

Binomial test was used to determine if there was any significant difference between the proportion of farmers that were satisfied and those not satisfied with the training received from the extension agents training programme. The formula for binomial distribution is given as follows:

$b(x;n,p) = nCx*px*(1-p)\ n-x$

Where b = binomial probability; x = total number of successes (satisfied or not satisfied); p = probability of success on an individual trial; n = number of trials

Decision rule: In making a decision, the possible values of the test statistics are divided into two ranges. The critical region of the sample distribution is the area or areas of the sampling distribution of a statistics that will lead to the rejection of the hypothesis tested when that hypothesis is true (Okwuokenye, 2020).

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

The socio-economic characteristics of the respondents is shown in Table 1. It revealed that most (64.86%) of the extension agents trained farmers were males while females constituted the minority (35.14%). The result suggest a poor response of females participation in public groups. This result is in line with that of Mgbada (2006) who reported low women participation in social groups. The mean age of the respondents was 45.27 years with most (36.94%) of them between the age bracket of 40 – 49 years, thus indicating that they are young and active. The average household size of the respondents was 6 persons with the modal (56.76%) having between 4 – 6 persons in their households. This indicates that they have people who depend on them for survival. Similarly, marital status showed that majority (73.87%) of the farmers were married, indicating that they are responsible. Similar results on low women participation in training groups, similar household size range (4 – 6 persons) and marital status was reported by Okwuokenye and Akintoye (2016).

The respondents educational level showed that most (66.67%) of them schooled up to secondary educational level. This implies that they are literate. The average farm income of the respondents was ₦328,378.38 and most (31.53%) of them earned between ₦300,001 – ₦400,000. The amount earned from farming is an indication that training has impacted positively on the farmers productivity and income. The results on farmers education and impact of training on productivity agree with findings of Okwuokenye and Urhibo (2019) which indicated that farmers who participate in groups are mostly literate and that such participation in training do well in helping to boost farmers output and income. Respondents average farm size was reported to be 2.75 ha. and most (61.26%) of their farm size was between the range of 2.1 – 4.0 ha. This indicates that they are small-scale farmers. Respondents farm experience revealed that the average was 10.06 years with most (40.54%) of them having between 10 – 14 years experience in farming, thus indicating that the respondents are experienced in farming operations. Results of Ovharhe (2014) revealed similar farm size and experience of farmers in Delta State.

Table 1: Socio-economic characteristics of respondents. n = 111

Characteristics	Categories	Frequency	Percentage	Mean
Sex	Male	72	64.86	
	Female	39	35.14	
Age	< 30	14	12.61	
	30 – 39	19	17.12	
	40 – 49	41	36.94	
	50 – 59	24	21.62	
	≥ 60	13	11.71	45.27
Marital status	Single	11	9.91	
	Married	82	73.87	
	Divorced	14	12.61	
	Widow(er)	4	3.60	
Educational level	Pri. Educ.	6	5.41	
	Secondary educ.	74	66.67	
	Post-secondary educ.	31	27.93	
Household size	1 – 3	12	10.81	
	4 – 6	63	56.76	
	7 – 9	26	23.42	
	10 – 12	7	6.31	

	≥ 13	3	2.70	6
Farm size (ha.)	≤ 2	31	27.93	
	2.1 – 4.0	68	61.26	
	4.1 – 6.0	7	6.31	
	> 6	5	4.50	2.75
Farm experience (years)	< 5	16	14.41	
	5 – 9	33	29.73	
	10 – 14	45	40.54	
	15 – 19	12	10.81	
	≥ 20	5	4.51	10.06
Farm income (₦)	100,001 – 200,000	21	19.92	
	200,001 – 300,000	27	24.32	
	300,001 – 400,000	35	31.53	
	400,001 – 500,000	15	13.51	
	500,001 – 600,000	9	8.11	
	> 600,000	4	3.60	328,378.38

Source: Field survey, 2021

Level of productivity of the farmers trained by the extension agents

Table 2 shows the respondents level of farm productivity. The result revealed that most (58.56%) of the respondents had high level of farm productivity, while very few (5.41%) of them had low level of farm productivity. On a larger consideration, about 94.59% of the farmers had productivity level that was of average and above in consideration. Okwuokenye and Urhibo (2019) share similar considerations in terms of impact of training on farmers productivity and income.

Table 2: Level of productivity of the farmers from extension agents training programmes (n = 111)

Level of Productivity	Frequency	Percentage
- Very High	16	14.41
- High	65	58.56
- Average	24	21.62
- Low	6	5.41

Source: Field survey, 2021

Effect of training of farmers on improved farm technologies by Extension Agents

The effects of training of farmers on improved farm technologies revealed that the average mean income earned by the farmers before and after receiving training was ₦247,297.30 and ₦328,378.38 respectively. The difference was ₦81,081.08 and in favour of the farmers after receiving training from the extension agents (see Table 3). This implies that training of farmers have positive impact on their productivity and farm income of the farmers and this was corroborated by the findings of Okwuokenye and Urhibo (2019).

Table 3: Effect of training of farmers on improved farm technologies by Extension Agents

	Income of farmers before training			Income of farmers after training		
Farm income (₦)	**Freq.**	**%**	**Mean**	**Freq.**	**%**	**Mean**
< 100,000	15	13.51		-	-	
100,001 – 200,000	21	18.92		21	19.92	
200,001 – 300,000	39	35.14		27	24.32	

300,001 – 400,000	26	23.42		35	31.53	
400,001 – 500,000	8	7.21		15	13.51	
500,001 – 600,000	2	1.80		9	8.11	
> 600,000	-	-	247,297.30	4	3.60	328,378.38

Difference in income before and after training = ₦328,378.38 - ₦247,297.30 = ₦81,081.08
Source: Field survey, 2021

Level of satisfaction derived by farmers from extension agents training programmes

Farmers' level of satisfaction from participating in extension agents training programmes is shown in Table 4. It revealed that most (49.55%) of the farmers are just satisfied with extension agents training programmes. On a broader classification, a large fraction (88.29%) of the farmers had a reasonable level of satisfaction, while only a small fraction (11.71%) had a satisfaction level that was below average. The result generally implies that the level of farmers' satisfaction with extension agents training was high and encouraging. The result agrees with reports of Okwuokenye and Urhibo (2019) which stated that majority of extension agents operating in Delta State are performing above average.

Table 4: Level of satisfaction derived by farmers from extension agents training programmes (n = 111)

Level of Satisfaction	Frequency	Percentage
- Very High	19	17.12
- Just High	55	49.55
- Averagely High	24	21.62
- Fairly High	8	7.21
- Not High	5	4.50

Source: Field survey, 2021

Agricultural services carried out by Extension agents on farmers

Table 5 shows the various agricultural services rendered to the farmers by the extension agents and this was measured by a weighted mean index of 2.50. Transportation / distribution of farm products services, Marketing services and Crop production services were the first three agricultural services agreed by the farmers been rendered to them respectively had means of 3.60, 3.58 and 3.42. The fourth, fifth, sixth and seventh ranking services offered to the farmers by the extension agents were advisory services (mean = 3.14), farm management services (mean = 3.05), financial services (mean = 2.89) and land preparation (mean = 2.51). The aforementioned services are in line with the findings of Anyoha *et al*. (2018) that revealed services like transportation, marketing, crop production, advisory, farm management, financial and land preparation as major services carried out by the extension agents in where farming is concerned.

Table 5: Agricultural services rendered to farmers by extension agents. n = 111

Agricultural services	Mean	Standard Dev.	Ranking
- **Financial services**	2.89	0.73	6th
- **Advisory services**	3.14	0.67	4th
- **Land preparation services**	2.51	0.89	7th
- **Crop production services**	3.42	0.57	3rd
- **Farm management services**	3.05	0.63	5th
- **Marketing services**	3.58	0.55	2nd
- **Transportation / distribution of farm products services**	3.60	0.50	1st

**Regular (mean ≥ 2.5), Source: Field survey, 2021*

Derived benefits by farmers from participating in extension agents training programmes

The benefits derived by farmers from participating in extension agents training programmes are shown in Table 6. Training of farmers on input use (mean = 3.68), advisory role of extension agents (mean = 3.43) and demonstrating on input use (mean = 3.16) respectively ranked 1st, 5th and 10th benefits derived by farmers from participating in extension agents training programmes. These findings are in line with the results of Okwuokenye and Urhibo (2019) which identified these aforementioned functions as regular roles of extension agents in groups. Information on crop protection (mean = 3.52) and access to financial services (mean = 3.36) respectively ranked 4th and 6th benefits derived by the farmers. Anyoha *et al.* (2018) confirmed these functions amongst others as those impacted on farmers by extension agents through the use of Information Communication Technologies (ICTs). In addition, access to farm input (mean = 3.60) ranked 3rd and production of services that can improve produce (mean = 3.27) ranked 8th of the derived benefits from their participation in extension training programme. Other perceived benefits were increased yield of produce (mean = 3.65), ability to control pest and diseases (mean = 3.36), increased farm income therefore enhanced farmers welfare (mean = 3.21) and improvement of quality of produce (mean = 3.08). These later factors ranked 2nd, 6th, 9th and 11th most derived benefits respondents get from training received from extension agents training programmes. These results are in consonance with findings of Madukwe (2005) who opined that training of farmers helps to improve on their farm production and income.

Table 6: Perceived benefits derived by farmers from participating in extension agents training programmes

Perceived benefits derived from extension agents training	Mean	Standard Dev.	Ranking
- Training of farmers on farming activities	3.68*	0.73	1st
- Increase in yield of produce	3.65*	0.75	2nd
- Provision / access to farm inputs	3.60*	0.78	3rd
- Information on crop protection	3.52*	0.81	4th
- Advisory role of extension agents to farmers	3.43*	0.81	5th
- Access to financial services	3.36*	0.85	6th
- Ability to control pest and diseases	3.36*	0.83	6th
- Production of services that can improve produce	3.27*	0.76	8th
- Demonstrating on input use	3.16*	0.79	10th
- Improvement in quality of produce	3.08*	0.86	11th
- Help farmers avoid harvest losses	2.41	0.88	12th

Agreed (Mean ≥ 3.00); Source: Field survey, 2021

Test of difference of farmers that are satisfied and those not satisfied with extension agents training programme

The test of significant relationship between farmers that are satisfied and those that are not satisfied with extension agents training programmes was carried out with the use of Binomial test and this is shown in Table 7. The result revealed that a larger proportion (87.39%) of the farmers was noted to be satisfied with the extension agents training programmes. On a statistical consideration, the result was significant at the 1% level of probability and for this reason, the alternative hypothesis was accepted and it states that: there is a significant difference between farmers that are satisfied and those that are not satisfied with the extension agents training programme. It therefore implies that the extension agents have performed creditably and such is evident in their level of productivity. This result is in conformity with that of Okwuokenye and Okoedo-Okojie (2014) which indicated that the extension agents serving in the Delta State are meeting up with their assigned task and thus helping to boost farmers output and income.

Table 7: Test of difference in CBO farmers satisfaction with extension agents farming programme

Satisfaction Status	Frequency	Percentage	Prob. Level
Satisfied	97	0.8739	0.001
Less satisfied	14	0.1261	
Total	111	1.0000	

Source: Field survey, 2021

CONCLUSION

From findings, it was concluded that most of the farmers who participate in extension agents training are males who are married, strong and active. They are also small-scale farmers who are literate and experienced in farming. Most of the farmers were satisfied with the extension agents training programmes carried out on them and this is evident in the benefits derived from their participation in the training programmes.

RECOMMENDATIONS

Based on findings, the study recommends that: women should be encouraged to participate in training programmes since these women are known as stake holders in where farming is concerned. This has become necessary since they were observed to have low participation in extension agents training programmes.

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Socio-Economic Determinants of Adoption of Agricultural Extension Strategies by Farmers in Umuahia South LGA of Abia State, Nigeria

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ABSTRACT

The study focused on the socio-economic determinants of adoption of agricultural extension strategies by farmers in Umuahia South LGA of Abia State. The specific objectives were to describe the socio-economic characteristics of the respondents, identify agricultural extension strategies extended and determine the effect of socio-economic characteristics of the farmers on adoption of Agricultural extension strategies. Multistage random sampling technique was employed. Data were collected from 120 respondents using a structured questionnaire. Data obtained were analyzed using descriptive and inferential statistics. The result shows that the likelihood ratio test has a significant value of -37.26 implying that the estimated model is statistically significant. Hence the model is considered to be good fit. R^2 implies that about 65% of the adoption by the respondents were due to the variables included in the model. This implied that the model consists of most of the determinants for Farmers Adoption of Agricultural Extension Strategies for Poverty Alleviation in the study area. The study recommends that emphasis should be made on education so as to equip the people with the necessary information they need to move out of poverty, farmers should be encouraged to form association so as to enable them easily obtain loans and credit facilities, as well as pool resources together, participatory extension service should be practiced which enable farmers to determine and accept change, when farmers determine changes, they agree to it and actively partake in it. The changes should be such geared towards improving their livelihood, and income.

Keywords: Socio-economic, extension strategies, determinants, adoption, Farmers.

INTRODUCTION

Agriculture is an important sector in the economic development and poverty alleviation drive of many countries. The importance of this sector is more pronounced in developing countries including Nigeria, where it is the main thrust of national survival, employment, food and foreign exchange (Adebayo and Okuneye, 2020). With the globalization of agriculture, major emphasis is laid on increasing productivity. Major emphasis has been given on production-led extension in the past (FAO,2010). Farmers have received most of the production technologies from the extension system. The extension system needs to be oriented with the knowledge and skills related to the market. This revamping of extension system will certainly play a catalytic role for ushering in farmer-led and market–led extension (Nwaneri, 2018) which can alleviate poverty. Birner (2006) highlighted the importance of institutional reconstructing and renewal, and decentralized extension structure. Recently, many developing countries have reaffirmed the essential role that agricultural extension can play in agricultural development as pointed out by Birner (2006) and Anderson (2007). In Nigeria, the incidence of poverty has been high and upward swinging since 1980. The rising profile of poverty in Nigeria is assuming a worrisome dimension as empirical studies have shown. Nigeria, a sub-Saharan African country, has at least half of its population living in abject poverty (Onoh and Peter-Onoh, 2012). Similarly, the publication of the Federal Office of Statistics (FOS, 1996) reveals that poverty has become massive, pervasive and engulfs a large portion of the Nigerian society. Nwaneri et al., (2021) states that the scourge of poverty in Nigeria is an incontrovertible fact, which results in hunger, ignorance, malnutrition, disease, unemployment, poor access to credit facilities and low life expectancy as well as a general level of human hopelessness. He asserts that Nigeria presents a paradox. The country is rich, but the people are poor. Onoh and Peter-Onoh (2012) perspicaciously remarked that Nigeria has witnessed a monumental increase in the level of poverty. According to them, the poverty level stood at 74.2% in the year 2000. It is indeed sad that twenty years after, poverty has been on the increase among its populace.

MATERIALS AND METHODS

Study Area Description

The study was conducted in Umuahia South Local Government Area of Abia State, Nigeria. The headquarters is at Apumiri-Ubakala. It has an area of 140km^2 and a population of 138, 570 people (NPC, 2006). Umuahia South L.G.A lies within Latitudes 5^0 31' and 9^0 68'' North of the Equator and Longitudes 7^0 29' and 10^0 60'' East of the Greenwich meridian (Wikipedia, 2017) and elevation of 55 meters above sea level. The climate is tropical and humid all year round. Annual rainfall ranges from 2000mm to 2500mm while the temperature ranges from 22^0C and 31^0C. It has 23 autonomous communities and 36 villages. The major occupation of the people is farming. Multistage random sampling technique was employed in the selection of respondents for the study. Firstly:3 communities were randomly selected from the 23 Autonomous Communities in the L.G.A. Secondly:4 villages were randomly selected from each of the selected communities, making a total of 12 villages. Stage three: 10 farmers were randomly selected from each of the selected villages giving a total of 120 respondents as sample size. A semi-structured questionnaire was used in soliciting information from the respondents. Objectives i and ii were analyzed using descriptive statistics such as percentages and frequency counts presented in tabular forms while objective iii was achieved using logit regression analysis. The explicit form of the model is represented thus;

$Y = {}_{g0} + {}_{g1}X_1 + {}_{g2}X_2 + {}_{g3}X_3 + {}_{g4}X_4 + {}_{g5}X_5 + {}_{g6}X_6 + {}_{g7}X_7 + ut$

Where;

Y = Adoption of the technologies (Adopted = 1, not adopted = 0)

X_1 = Age of respondent (years as supplied by the respondents)

X_2 = Gender of Respondent (dummy; male 1, female 0)

X_3 = Income level of respondents (# measured in Naira)

X_4 = Household size of respondents (number of people living together in a house)

X_5 = Farm size of respondents (Ha)

X_6 = Educational qualification of respondents (years measured in years of formal schooling)

X_7 = Marital status (dummy, variable; married 1, otherwise 0)

g_1–g_7 = Estimated parameters

g_0 = autonomous level of production known as the constant.

RESULTS AND DISCUSSION

Table 1 shows the socio-economic characteristics of Respondents. The result indicates that majority (67.50%) of the farmers were males. The dominance of male farmers is probably because the males own most of the farm assets including farm lands and therefore had an edge over the females. This is in line with Nwaneri (2018), who opined that training services should primarily be directed towards men because they are more likely to adopt technologies faster than the females. The table further shows that farmers within the age bracket ranged between 20-39 years were in majority (42.5%). This implies that most of the respondents were married. Age is vital in Agricultural production especially labour which is intensive and could be better accomplished by able bodied and energetic individuals, (Nwaneri et al.,2021). Majority (96.66%) of the respondents were educated attaining various levels of education. This implies that the respondents had one qualification or the other ranging from WAEC to BSC. The level of education attained by a farmer not only increases his farm activity, but also enhances his ability to understand and evaluate new production technologies (Nwaneri, 2018). The table further revealed that majority (40.83%) of the farmers had household sizes between 4-6. The implication of this revelation is that large household sizes is an advantage to farmers in terms of labour supply. Large household size has shown to provide cheap labour, especially where labour wages are costly. It is therefore expected that the family embarks on technologies that will increase their farm output. A fair proportion (47.50%) of respondents were married with farm sizes between 2-3 hectares, this is a clear indication that the farmers are small scale farmers (Nwaneri,2018).

Table 1: Characteristics of Respondents in Umuahia South L.G.A, Abia State (N= 120)

Characteristics	**Frequency**	**Percentage**
Gender		
Males	81	67.50
Females	39	32.50
Age (years)		
20 – 39	51	42.50
40 - 59	42	35.00
60 – Above	27	22.50
Marital Status		
Single	45	37.50
Married	57	47.50
Widow	11	9.17
Widower	7	5.83
Level of Education		
No formal education	4	3.33
Primary school	31	25.83
Secondary school	36	30.00
Tertiary school	49	40.83
Household size		
1 – 3	47	39.17
4 – 6	49	40.83

7 - 9	22	18.33
10 – Above	2	1.67
Farm size (Ha)		
0.1-1	40	33.33
2-3	56	46.67
4-5	15	12.50
6 - Above	9	7.50
Total	**120**	**100**

Source: *Field Survey data,2021*

The distribution of respondents according to Agricultural extension strategies extended to them is shown in Table 2. The table revealed an overwhelming (100%) indication of the extension strategies like; agricultural capacity building, participatory extension, focus on high value enterprises, formation of farmers' association, formation of self-help groups, farmer to farmer extension and community empowerment were the strategies extended to respondents in the study area. While T & V based extension strategy and workshop and seminars had fairly good proportion (77.50% and 81.67% respectively) indication as being available in the area. It is one thing for an innovation to be available and a different thing for the technology to be utilized (Nwaneri., *et al* 2019; Nwachukwu and Onuegbu, 2005).

Table 2:Distribution of Respondents According to Agricultural Extension Strategies Extended in Umuahia South LGA.

Packages Extended	*Frequency	Percentage
Agricultural Extension Capacity Building	120	100.0
T & V Based Extension Strategy	98	77.50
Workshop and Seminar	93	81.67
Participatory Extension Strategy	120	100.0
Focus on High Value Enterprises	120	100.0
Formation of Farmers Association	120	100.0
Formation of Self-help Groups	120	100.0
Farmer to Farmer Extension	120	100.0
Community empowerment	120	100.0

Source: *Field Survey Data,2021*
*Multiple responses recorded

The result on the table 3 shows that the likelihood ratio test has a significant value of -37.26 implying that the estimated model is statistically significant. Hence the model is considered to be good fit. R^2 implies that about 65% of the adoption by the respondents were due to the variables included in the model. This implied that the model consists of most of the determinants for Farmers Adoption of Agricultural Extension Strategies for Poverty Alleviation in the study area. Therefore, among the variables tested, coefficient of age of the farmers was negative and statistically significant at 1% level of probability, which implies that as the age of the farmers' increases, the rate at which they adopt the strategies decreases. This does not align with the researcher's *a priori* expectation since increase in age may decrease the farmers' agility, zeal or interest in farming and as well lead to decrease in adoption of extension technology packages. This does not submit to the findings of Nwaneri *et al* (2019) which reported that older farmers are risk averse and so may not adopt improved technologies. However, the coefficient of gender was positive and statistically significant at 5% level of probability. This implies that as more male farmers involve in the programme, the adoption of the strategies increase. This may be because the male farmers have more resources such as land to practice the newly introduced innovation than the females. This connotes that gender of farmers influences the adoption of extension technology packages among rural farmers in the area. This does not align with the *a priori* expectation given that both males and females have equal opportunities to adopt extension technology packages if they have the capacity to do so. This corroborates the report of Nwaneri (2018) who opined that both males and females have equal adoption to improved technologies. On the contrary, the coefficient of annual income was negative and statistically significant at 1% level of probability, this implies that as the income of the farmers' increases, the farmers' adoption of the strategies decreases. This could be because the more income a farmer has determine his or her tendency to engage in the other businesses than the agricultural activities.However, the coefficient of education was positive and statistically significant at 10% level of probability implying that the educated farmers had greater participation in agriculture in the study area. The innuendo is that any increase in quality of education acquired by the farmers will directly lead to increase in the farmers' adoption of extension technology packages and vice versa. This succumbs to the *a priori* expectation of the researcher who noted that access to quality education is an expository value which places farmers to quickly understand the usefulness of an extension technology and as such enhance adoption. This sees eye to eye with the finding of Nwachukwu and Onuegbu (2005) who argued that increase in access to quality education increases farmers' adoption of improved technologies in the area. Similarly, the coefficient of the marital status was positive and statistically significant at 1% level of probability. This implies that as the farmer gets married, so adoption of strategies to alleviate poverty increases. This is in agreement with the findings of Onoh and Peter-Onoh (2012) who disclosed that married people have higher family responsibilities to meet and so are under much pressure to adopt improved technologies to improve yield for better family enhancement.

Determinants of Farmers Adoption of Agricultural Extension Strategies for Poverty Alleviation in Umuahia South LGA of Abia State, Nigeria.

Table 3: Logit Regression Result on factors influencing Agricultural Extension Strategies adoption in the study area.

Variables	Coefficient	z- value
Constant	4.954525	2.03**
Age	-1.80772	-3.69***
Gender	0.6839029	1.98**
Income level	-1.205974	-2.83***
Household size	0.1640564	0.41
Farm size	-0.5699544	-1.24
Education qualification	0.6661129	1.92*
Marital status	4.044248	5.01***
Psudo R^2= 0.6454LR	chi(7) = 64.65***	log likelihood = --37.26***

Sources: Field survey data, 2021.

**** and * shows significant at 1%,5%and10% level of probability respectively.**

CONCLUSION AND RECOMMENDATION

The study analyzed the socio-economic determinants of adoption of agricultural extension strategies by farmers in Umuahia South LGA of Abia State, Nigeria. The result on socio-economic characteristics indicates that majority (67.50%) of the farmers were males while their age bracket ranged between 20-39 years. This implies that most of the respondents were married. Majority (96.66%) of the respondents were educated attaining various levels of education. This implies that the respondents had one qualification or the other ranging from WAEC to BSC. The result further revealed that majority (40.83%) of the farmers had household sizes between 4-6. The implication of this revelation is that large household sizes is an advantage to farmers in terms of labour supply. A fair proportion (47.50%) of respondents were married with farm sizes between 2-3 hectares, this is a clear indication that the farmers are small scale farmers (Nwaneri,2018). It was observed that socio-economic characteristics of the farmers actually influenced their adoption of Agricultural extension strategies. There is a greater chance that people, will participate in extension activities and high income ventures if they are empowered. Based on the findings of this study the following recommendations were made: Emphasis should be made on education so as to equip the people with the necessary information they need to move out of poverty, farmers should be encouraged to form association so as to enable them easily obtain loans and credit facilities, as well as pool resources together, participatory extension service should be practiced which enable farmers to determine and accept change, when farmers determine changes, they agree to it and actively partake in it. The changes should be such geared towards improving their livelihood, and income.

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Selected Socio-Economic Factors Affecting Homestead Garden Egg Production in Ezza North Local Government Area of Ebonyi State, Nigeria.

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ABSTRACT

The study evaluated selected socio-economic factors affecting homestead garden egg production in Ezza North Local Government Area of Ebonyi State, Nigeria. The specific objectives were to describe the socio-economic characteristics of the respondents and evaluate the socio-economic factors affecting homestead garden egg production by the farmers in the study area. A structured questionnaire was administered to 90 respondents randomly selected from Ezza North LGA of Ebonyi State. Data obtained were analyzed using descriptive and inferential statistics. It was observed that socio-economic characteristics of the farmers actually affected Homestead Garden Egg Production in the area such as gender and marital status as shown on the regression result which indicated that R^2 of 0.5801 as observed in the model implies that about 58% of the variation in the quantity of garden egg harvested was as a result of the factors included in the model. The overall fitness is confirmed by the significant f-value. Based on the findings of this study the following recommendations were made: there is need for government to promote extension services by allocating sufficient funds to facilitate extension staff to reach farmers frequently to teach them the new ideas in garden egg production, farmers' financial problems may be solved through access to loans from commercial banks, microfinance banks and other lending agencies probably by forming or joining cooperative societies.

Keyword: Homestead, Garden egg, Production, Socioeconomic, Factors

INTRODUCTION

Generally, home gardening refers to the cultivation of a small portion of land which may be around the household or within walking distance from the family home (Abu *et al*.,2017). Homestead gardens are also called kitchen gardens, backyard gardens, compound gardens, rooftop gardens, is a type of agriculture that has been in practice since the beginning of the agricultural system. It is a garden not far from the home that is owned and maintained by the household and kept mainly for household food supply (Balogon, 2016). Among common vegetable crops seen in a typical Nigeria homestead garden include, fluted pumpkin, bitter leaves, water leaves, garden egg, beans, curry, scent leaves among others. A homestead vegetable crops which is to be given priority under this study is garden egg. Garden egg or scarlet eggplant (Solanum aethiopicum) is one of the most important vegetable crops in tropical Africa. Garden eggplants are fruit vegetables of some varieties which are white and shaped like chicken eggs, hence the name 'eggplants' (Ahmed, *et al*., 2016).

Among many crops which are important nutrient dietary that no much attention seem to have been given by research or neglected by governments and farmers in Nigeria in particular is garden egg, (Ahmed, *et al*., 2016; Amoako, J. (2017). The neglect could be attributed to among others; lowly contribution to the nation's foreign exchange, (Akpan, 2014), ignorance of the nutritive values and diversified food forms from garden egg, by greater percentage of the populace (Akpan, 2014), poor acceptance by high income countries for both consumption and other purposes and high labour intensive nature of its production entails almost has zero mechanization (Enete and Okon 2018).

MATERIALS AND METHODS

Study Area Description

The study was carried out in Ezza North Local Government Area of Ebonyi State, Nigeria. Ezza North shares boundaries with Ikwo in the East, North-East and Southeast with Ezza South and Abakaliki in the North and Onicha in the West and Southwest. The mean temperature is 28^0C- 42^0C, having an annual rainfall of 1800mm - 2000mm, relative humidity of 65%. It is located between Latitude 6^049^l and 6^032^l North of Equator and Longitude 8^03^l and 7^098^l East of the Greenwich meridian. The people are mostly farmers who take advantage of the rich and abundant farm land to cultivate yam, rice, garden egg, cassava, cereals and vegetables, among others. It has an area of 324km^{2}and population of 133,625(NPC, 2006). Multistage random sampling technique was employed in the selection of respondents for the study. Firstly, 2 communities; Umuezekaoha and Oshiegbe were randomly selected because of their massive involvement in the production of garden egg. Secondly, 3 villages (Okwuhieonu, Agbo and Izenyi) were selected from Umuezekaoha community while 3 villages (Azomele, Azuda and Odeligbo) were selected from Oshiegbe to give a total of 6 villages. Thirdly, 15 garden egg farmers were randomly selected to give 90 respondents. A structured questionnaire was used in soliciting information from the respondents. Objective i. was analyzed using descriptive statistics such as percentages and frequency counts presented in tabular forms while objective ii was achieved using regression analysis. The explicit form of the model is represented thus;

Linear form:

$Yd = f(X_1, X_2, X_3, X_4, X_5, X_6...... +e_i$ (explicit form)

$Yd=a+b_1x_1+b_2X_2+b_3X_3 +b_4X_4+b_5X_5+b_6X_6...... +e_i$ (implicit form)

Semi log form:

$Yd=a+b_1logX_1+b_{29}logX_2+b_3logX_3+b_4logX_4+b_5logX_5+b_6logX_6 ....+e_i$

Double log form:

$Log Yd=a+b_1logX_1+b_2logX_2 +b_3LogX_3 +b_4logX_4+b_5logX_5+b_6logX_6 ....e_i$

Exponential form:

$LnYd=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6 ....+e_i$

Where

Y_d = Output of garden egg by rural household farmers (kg)
X_1 = Age of the farmers (years)
X_2 = Marital Status (single=1, married=2, widow=3, widower=4, divorced=5)
X_3 = Household size (number of persons)
X_4 = Gender (male = 1, Female = 0)
X_5 = Educational qualifications (years of formal schooling)
X_6 = Farming Status (in time duration)
X_7 = Farming Experience (in years)

X_8 = Access to credit facilities (yes=1, No=0)
X_9 = Agro-chemical (herbicides =1, pesticides=0)
X_{10} = Extension contact (yes=1, No=2)
e_i = Error term

RESULTS AND DISCUSSION

Table 1 shows the socio-economic characteristics of Respondents. The result showed that 61.11% of the respondents were at the age bracket of 31-50. This implies that the respondents were young and very active to go into garden egg production. The finding also conformed to those of Nwaneri et al., (2021) that most farmers in Nigeria are above 40 years. The result also showed that 65.56% were female. This implies that most of the garden egg farmers in the area were female. The result further showed that 44.44% of the respondents were married. This implies that most of the garden egg producers in the area were married which means that they have farming to care for. The involvement of married class in agriculture is in line with Nwaneri., et al (2021) whose report shows that married class are more involved in agriculture because of the need to supplement the families' means of livelihood. Majority (38.89%) of the respondents had household size of 4 to 6 persons while 75% of them were educated attaining various levels of education. The level of education attained by a farmer not only increases his farm activity, but also enhances his ability to understand and evaluate new production technologies (Nwaneri, et al., 2021). Also, 41.11% had farm size of 0.1-0.5 indicating that the respondents engaged in small scale production as their major source of labour is both family and hired labour, while a good proportion (87.78%) belonged to cooperative society or farmers' association. These implies high innovativeness among the respondents due to influence of good dynamic effects. The involvement of farmers in association or cooperatives enabled them share ideas and work as a unifying force (Nwaneri et al., 2019). The result further showed that majority of the respondents (91.00%) do not have access to extension visit while a large proportion (72.27%) of the respondents do not have access to credit facility which resulted to reduction in the production level of garden egg. This agrees with the findings of (Nwaneri et al., 2019) who posited that having access to credit facility is opening a way for increase in productivity.

Table 1: Characteristics of Respondents in Ezza North L.G.A, Ebonyi State (N= 90)

Characteristics	Frequency	Percentage
Gender		
Males	31	34.44
Females	59	65.56
Age (years)		
<30	10	11.11
31 - 50	55	61.11
61 – Above	25	27.78
Marital Status		
Single	15	16.67
Married	40	44.44
Divorced	25	27.78
Widow	10	11.11

Household Size		
1 – 3	30	33.33
4 – 6	35	38.89
7 – 9	25	27.78
Level of Education		
No formal education	15	16.67
Primary school	45	50.00
Secondary school	25	27.77
Tertiary school	5	5.56
Farm size(ha)		
0.1 – 0.5	37	41.11
0.6 – 1.0	21	23.33
1.1 – 1.5	17	18.89
1.6 – 2.0	15	16.67
Source of Labour		
Family	6	6.67
Hired	25	27.77
Both	59	65.56
Cooperative Society		
Yes	79	87.78
No	11	12.22
Extension visit		
Yes	9	10.00
No	81	91.00
Access to Credit Facility		
Yes	9	10.00
No	81	91.00

Source:Field Survey,2021

Table 2 showed the multiple regression result of effect of Socio-economic Characteristics of homestead garden egg farmers on their Output. Among the models fitted, linear model was chosen as the lead equation because it satisfied the economic criteria of highest R^2 value (0.5801), the highest number of the significant variables (gender, marital status, membership of cooperative, extension contact, household size, access to credit and farm size) and the high f-value (15.06). The R^2 of 0.5801 implies that about 58% of the variation in the quantity of garden egg harvested was as the result of the factors included in the model. The overall fitness is confirmed by the significant f-value. The coefficients of gender, marital status, membership of cooperative and extension contact were negative and statistically significant at 1% level of probability. This implies that as the number of males involved in garden egg production increases, the quantity of garden egg harvested decreases. Also, as the number of married farmers increased, the quantity produced decreases. As the farmers belong to cooperatives, theirs contact to extension services increases and the introduction of innovations increases which deviates the farmers interest on the garden egg production, thus reduces the quantity of garden egg produced. However, the coefficients of household size, farm size and access to credit were positive and statistically significant at 1% level of probability. This implies that as the family size of a farmer increases, the farmer has more access to finance which enables him to acquire more lands; with which he practices other innovations and still increase the quantity of garden egg produced in the area.

Table 2 Regression Result on the Relationship between the Socio-economics Characteristics of the homestead garden egg farmers and their Output.

Variables	Linear +	Semi-log	Double log	Exponential
Constants	40.67716 (0.65)	3.739165 (4.93)***	3.072135 (3.61)**	2.46e+33 (1.12)
Age	4.871315 (-1.11)	0.0210311 (0.34)	-0.1805582 (0.95)	-2.35e+31 (-1.04)
Gender	-14.35986 (-2.63)***	-0.1252409 (-1.88)*	-0.5656173 (-2.85) ***	-3.07e+30 (-0.32)
Marital status	-9.427452 (-3.00)***	-0.0913898 (-2.38)**	-0.2828353 (-1.38)	-2.37e+29 (-0.02)
Household size	15.48083 (2.74)***	0.1410842 (2.04)**	0.4041941 (1.78)*	-5.38e+29 (-0.58)
Education	-6.252995 (-1.44)	-0.0393301 (-0.74)	-0.0898158 (-0.59)	-3.02e+30 (-0.36)
Farm size	36.23185 (5.19)***	0.3902401 (4.58)***	1.394134 (5.58)***	1.98e+30 (0.30)
Source of labour	-4.70762 (-1.30)	-0.0782061 (-1.77)*	-0.2893293 (-1.48)	3.19e+29 (0.34)
Cooperative society	-14.08403 (-2.90)***	-0.1512104 (-2.55)**	-0.4565885 (-2.65)**	-5.38e+29 (-0.02)
Extension services	-10.16649 (-2.64)***	-0.107503 (-2.29)**	-0.2233304 (-1.57)	1.98e+30 (0.34)
Access to credit	18.88533 (5.38)***	0.1869211 (4.36)***	1.053084 (4.52)***	2.46e+33 (0.30)
R^2	0.5801	0.5167	0.5156	0.0238
F-ratio	15.06***	11.65***	11.60***	0.20

Source, *Field Survey, 2021* ***,**and * shows significant at 1%,5% and 10% level of probability. Values in bracket represent the T-values.

CONCLUSION AND RECOMMENDATION

The study evaluated Selected Socio-Economic Factors Affecting Homestead Garden Egg Production in Ezza North Local Government Area of Ebonyi State, Nigeria. The result showed that 61.11% of the respondents were at the age bracket of 31-50. This implies that the respondents were young and very active to go into garden egg production. The result also showed that 65.56% were female. This implies that most of the garden egg farmers in the area were female while 44.44% of the respondents were married. This implies that most of the garden egg producers in the area were married which means that they have farming to care for. Furthermore, 38.89%) of the respondents had household size of 4 to 6 persons while 75% of them were educated attaining various levels of education. Also, 41.11% had farm size of 0.1-0.5 indicating that the respondents engaged in small scale production as their major source of labour is both family and hired labour, while a good proportion (87.78%) belonged to cooperative society or farmers' association. These implies high innovativeness among the respondents due to influence of good dynamic effects. The result further showed that majority of the respondents (91.00%) do not have access to extension visit while a large proportion (72.27%) of the respondents do not have access to credit facility which resulted to reduction in the production level of garden egg. It was observed that socio-economic characteristics of the farmers actually affected Homestead Garden Egg Production in the area such as gender and marital status as shown on the regression result which indicated that R2 of 0.5801 as observed in the model implies that about 58% of the variation in the quantity of garden egg harvested was as a result of the factors included in the model. The overall fitness is confirmed by the significant f-value. Based on the findings of this study the following recommendations were made: there is need for government to promote extension services by allocating sufficient funds to facilitate extension staff to reach farmers frequently to teach them the new ideas in garden egg production, farmers' financial problems may be solved through access to loans from commercial banks, microfinance banks and other lending agencies probably by forming or joining cooperative societies.

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ABSTRACT

This study investigated the level of gender participation in the formal and informal markets in Southeast Nigeria. The study was carried out in Southeastern Nigeria to determine the participation of cassava value chain actors in the formal and informal market by gender. Multi-stage sampling procedure was used to in the selection of 432 respondents used for the using a well-structured questionnaire. Data were analyzed using simple descriptive statistics and inferential statistical tools. The results revealed that in the formal market, male producers and processors had 0.88 and 0.83 Market participation index which was adjudged to be high, while the marketers had only 0.37 of participation. The female gender had 0. 63 market participation index for the producers and marketers in the same market which was considered to be moderate. The results also revealed that all the male cassava value chain actors in the informal market had high market participation index (0. 80 and above). While their female counterparts had at least 0.55 Market participation index in all the chains. The study therefore recommends that The female actors should be given more access to land, inputs, credits and loan to enable them to participate more in the formal market and to create more value that may help them to be more productive, increase value in business and market oriented

KEYWORDS: Participation index, Percentage sales, Gender, Markets, Cassava value chain.

INTRODUCTION

Cassava is produced by smallholder farmers and it's strategically valued for its role in food security and poverty alleviation. Markets play a vital role in ensuring better incomes and welfare for farmers through diverse channels. Formal market refers to reliable (contract arrangement) and lucrative (profitable) markets or the high value markets while informal market on the other hand is a market where there is no involvement of any formal arrangement (e.g. contract) for a sale of goods between a farmer and a buyer. Market participation refers to the extent by which households participate in the market as a seller, (Berhanu and Moti, 2012)

The participation of men and female cassava value chain actors in the formal and in the open markets enhances the potential that unfolds economic opportunities that improves the value added along the chain. The terms upon which the actors enter and participate in formal or informal markets are sometimes inequitable (Osmani and Hossain, 2015). Women in agricultural production chains are excluded from transportation of goods to the market or from marketing or sales roles of goods, even when women are the main producers of these goods (International Finance Corporation, 2016). Lack of access to market and poor market information prevalent in Southeast always result in production and processing activities not well organized in line with consumer demand for cassava roots and processed-products.

Thus, cassava has been the focus of many market-led development initiatives, such as the Pan-African Cassava Initiative (PACI) launched by NEPAD and IITA in 2004; the Cassava: Adding Value for Africa project; and the Regional Cassava Processing and Marketing Initiative (RCPMI) with IFAD in West Africa among others. All these initiatives have worked and is still working to promote and uphold cassava development in different ways, as well as other activities to support increase in production and processing ability, from improving the agricultural inputs such as improved cassava varieties to the growth and expansion of new products to enhance market demand, and strategy guidelines to support growth in cassava commercial opportunities and value chains (Forsythe, Posthumus and Martin, 2016). Despite these initiatives, the practices, policies and programmes in cassava value chain are gender blind in market participation and do not consider women's unique needs and knowledge; unequal rights and responsibilities between men and women or limited participation of women in decision-making processes (World Bank, 2009). Therefore there is a dearth of information on gender differentials generally, or with respect to formal and informal market participation among cassava value actors in southeast Nigeria. Against this background, it becomes pertinent to examine the level of gender participation in the formal and informal markets by cassava chain value chain actors in Southeast, Nigeria.

METHODOLOGY

The study was carried in South-east agro-ecological zone of Nigeria. Using the multi-stage sampling procedure, three States were randomly selected. These were Imo, Abia and Ebonyi States. Secondly, two agricultural zones, according to the State ADP's delineation were selected from each State and two Local Governments based on the intensity of cassava production were purposively selected, given a total of twelve Local Government Areas. Two (2) communities known for intensity of cassava production were purposively selected from each of the selected Local Governments.

To ensure representative sample selection, a pre-survey sampling frame was determined by compiling lists of cassava producers, processors and marketers in the selected twenty four communities collected from the selected LGAs, village heads and the related associations in cassava value chain in the area. From these lists, six (6) producers (3 males and 3 females), six processors, (3 males and 3females) six marketers, (3 males and 3 females) were randomly selected, making a total of one hundred and forty four (144) for each of the producers, processors and marketers giving a sample size of four hundred and thirty two (432) respondents that were used for the study.

The study utilized primary data collected using structured questionnaire, informant interviews and focus group discussion. Data were analyzed using descriptive and inferential statistics.

The ***Level of gender participation in the formal and informal markets along the chain was analyzed using Market Participation Index.***

*The Market participation index is measured by the level of involvement in sales of cassava value products in the formal and informal markets along the chains. F*ollowing Osmani and Hossain, (2015), the level of participation in the formal and informal markets was derived using the following model stated as:

$$Mp_i = \frac{Vs_{ik}}{Vpm_{ik}} \times 100 \qquad (1)$$

Where:
Mp_i = Sales in the ith market type (percent)
Vs_{ik} = value of sales in the ith market type at the k^{th} stage (naira)
Vpm_{ik} = Total value of products for ith actor at the k^{th} stage
In this case, the model was used to measure the percentage sales in the formal and informal markets.

RESULTS AND DISCUSSIONS

Table 1: The Levels of Gender Participation among Cassava Value chain Actors in the Formal Market

	Formal market					
	Male			Female		
.	Prod.	Proc.	Mkter.	Prod.	Proc.	Mkter.
Quantity harvested/ processed/ purchased (Kg)	15012.83	2491.92	3878.98	15809	2290.51	3525.59
Quantity sold (Kg)	13333.1	2076.11	1436.43	10098.9	1003.85	2228.3
MPI-Level of participation (Qty Sold/Qty Harvested)	0.8881	0.8331	0.3703	0.6388	0.4383	0.6320
%age sales in the market	88.8114	83.3138	37.0311	63.8807	43.8266	63.2036

Source: Survey data, 2019,
Prod= producers, Proc = processors, Mkter= Marketers, MPI= Market Participation Index

The result of the level of market participation among male and female cassava actors were measured in percentage sales. The analysis showed that the level of male participation in the study area was high (88 and 83 percents) for the producers and processors and low (37%) for the marketers. For the female gender, the percentage sale in the formal market was also moderate (63% for both actors) for the producers and marketers. However, the result revealed that the level of female gender participation- for the processors was low with percentage sale of43%. The result is in contrast with the finding of Riisgaard; Fibla, and Ponte, (2010), who reported that small scale cassava processing is the domain of women. However, men are becoming more involved in cassava processing probably because it is becoming more lucrative. Other researchers have corroborated this finding and noted the trend of men operating processing plants and becoming managers of such enterprises as processing became increasingly commercialized and mechanized (Adebayo, Lamboll and Westby, 2008). This indicated that male producers and processors participated more in the formal market than their female counterparts. This might be explained by the fact that male farmers with bigger cultivable land were found to participate more because of their ability to produce bigger volumes that ensures marketable surplus. Lerman, (2004) revealed that farmers with large cultivable land were found to participate more because of their ability to produce larger volumes that ensured market surpluses. However, the female marketers participated more in the formal market than their male counterparts with only 37% sales.

Furthermore, the results of the analysis also show that while the male actors harvested 15012.83kg of fresh cassava roots they were able to sell 13,333.1kg at the formal market and probably consumed or disposed 1,679.73kg of their harvest. For the female producers, they had

15809kg of cassava roots, sold 10098kg and disposed the remaining 4990.1kg of their harvest. This result was similar for all the actors in the formal market. This implies that while the female actors harvested/processed/purchased more quantity of cassava products, they sold only a smaller portion unlike the male who sold more and probably consumed less. These findings confirm the fact that the male actors were more formal market oriented than their female counterparts. This observation was similar along the chain for the male and female processors in the formal market. The large amount- harvested by the male producer may be as a result of area cultivated with cassava compared with large total area held for agricultural activities as shown in the socio economic variables statistics. The higher proportion of land a household allocated to the more marketable crops, the more the household produced for market following the findings of Berhanu and Moti, (2012) and Okoye, (2018).

In the marketing chain, the male marketers in the formal market were able to sell 2228.3kg out of 3525.59kg of gari purchased, while their male counterpart sold 1436.42kg from 3878.98kg purchased. This confirmed the result of David and Madu, (2014) who noted that sweet potato and cassava crops were traditionally marketed by women while an increasing number of men were into production and cultivation of sweet potato on their own plots because of its high level of profitability.

Level of gender participation by cassava actors in the informal market

The result in Table 2 shows the level of gender participation among cassava value chain in the informal market.

Table 2: Level of gender participation in the informal market along the chain

	Informal market					
	Male			**Female**		
Variables	**Prod.**	**Proc.**	**Mrkt.**	**Prod**	**Proc.**	**Mrkt.**
Quantity harvested/processed/purchased (Kg)	16435.4	1979.62	2855	14888.95	1920	2821
Quantity sold (Kg)	13835	1800	2288.2	10125	1058.5	2767.5
MPI (Qty Sold/Qty Harvested)	0.8418	0.9093	0.80147	0.68004	0.5513	0.9810
%age sales in the market	84.1781	90.9268	80.1471	68.0035	55.1302	98.1035

Source: Survey data, 2019.. MPI= Market participation Index

Prod= producers, Proc.= processors, Mkter= Marketers

The result of level of gender participation in the informal market is presented in the Table 2. The level of participation for all the male actors in production, processing and marketing was high at 84, 91 and 80 percents respectively. For the female gender, the percentage sales were 68,55and 98 percents for the producers, processors and marketers respectively. The high market participation index for the male actors indicated that the male actors participate more in the market than their female counterparts in exception with the female marketers. This is against a prior expectation probably because most of the actors are aged and had preference to informal market more than the formal market because of their age. Although Adjimoti, (2013) in his study on market participation noted that male cassava actors have preference for the informal market more than their female counterparts.

CONCLUSION AND RECOMMENDATIONS

The male and female cassava value chain actors such as the producers, marketers and processors participate in the formal and informal markets as sellers based on the quantity of produce harvested, processed or sold. The male producers and processors had more Market participation index in the formal and informal markets more than the marketers. The female producers and processors had higher percentage sales in the formal and informal markets more than the processors. Relatively, the male participated more in the formal and informal markets than their female counterparts. The study therefore recommends that In view of the fact that both male and female cassava value chain actors participate in the formal and informal markets and take part in all aspects of cassava enterprise development activities, research should be geared to develop gender sensitive technologies for dissemination to both gender to enhance production, productivity and quality of processed products .Also the female actors should be given more access to land, inputs, credits and loan to enable them to participate more in the formal market and add more value that may help them to be more productive, increase value in business and market oriented.

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Covid-19 and Food Security Status of Farming Households in Cross River State, Nigeria

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ABSTRACT

The objectives of this study was to assess how the United States Food Security Module can be used to measure the food security status of farming households during corona virus disease lockdown in the study area, to determine the coping-strategies adopted by farming households and to compare the food security status of farming households in the three agricultural zones of the State. This study conducted in Cross River State used primary data which was obtained between April and May 2020 using questionnaire. Two hundred and forty (240) farming households were randomly selected from a list of registered farmers and a six-item short form of the United State's Food Security Survey Module was applied for the assessment. The findings revealed that majority of the households (rural households) were food insecure (64.58%) while only (35.42%) of households were food secure confirmed by the number of affirmative responses to 5 out of 6 questions in the survey module. Also, households with high food insecurity status employed more of the coping strategies such as reducing the amount of food consumed (18.75%), borrowing from family and friends (25%), selling small assets (25%) as well as acquiring additional job (20.83%) to survive. COVID -19 lockdown disrupted the food supply chains and cause a sharp rise in commodity prices beyond the reach of households. The state could cushion the impacts by introducing measures such as massive investment in agricultural sector, social assistance benefits like conditional cash transfer to vulnerable farming households and provision of agricultural inputs and credit facilities to farmers.

Keywords: *COVID-19, food security, farming household, lockdown, status*

INTRODUCTION

The corona virus disease (COVID-19) which was declared as pandemic by World Health Organization (WHO) on the 11th of March 2020 was actually first reported on the 31st of December, 2019 in China, precisely in Wuhan in the Province of Hubei. In Nigeria, the first case was reported on February 28, 2020 (Federal Ministry of Health (FMH) 2020). The disease usually starts with difficulty in breathing resulting to a Severe Acute Respiratory Syndrome virus (SARS-CoV-2) is the prime suspect (WHO, 2020). The virus disease like wild fire has spread worldwide with its resultant effect on lives and properties in addition to paralysis of economic and social activities across regions. However, interests have been growing on how poverty and food insecurity can be alleviated across the world particularly in this pandemic era. It is likely that African countries may be the worst hit by the corona virus disease in developing countries especially in the long-run (World Bank 2020). From experts advise, the aging population of several countries are the most at risks (Gardner *et al.*, 2020; Lima *et al.*, 2020), or poor infrastructural healthcare system (Tanne *et al.*, 2020; Mikhael *et al.*, 2020). Other emphasis has been place on the role of the environment naturally (Marco *et al.*, 2020) all of which are characteristics of African countries. Statistics globally with respect to Covid-19 as at October 22, 2020 indicates that total cases was 41, 570,428 resulting to 1, 137, 693 deaths and 30, 957,964 recoveries while similarly in Nigeria, the number of total infection as at October 22, 2020 was 61, 667 with 1,125 deaths and 56, 880 recoveries or discharged (www.worldometers.info/coronavirus). Covid-19 outbreak has heightened the threat to human lives and food security all brought about by the new wave of violence and conflict across the world. It therefore means that the capabilities of the states to protect her citizens are weaken and as such public goods and basic services may not be readily available. The livelihoods of several Cross Riverians and Nigerians have been lost due to the several lockdown orders for Covid-19 even though the State did not record any index case of Covid-19 within the period of this study thereby triggering an increase in conflicts, crime and violence.

In order to cope with the impact of Covid-19 pandemic, governments across the world provided measures to take care of their citizens and improve the economy as well as food security. Africa countries have responded with Nigeria rolling out the sum of N50 billion stimulus package for households and small and medium-scale enterprises (SMEs), "all CBN intervention facilities are hereby granted a further moratorium of one year on all principal repayments as well as interest rate reduction from 9 to 5 percent per annum for 1 year effective March 1, 2020" etc. (CBN, 2020, NCDC, 2020). In other words, Covid-19 has resulted in a give and take situation even though what it takes is greater than what it gives. Keeping aside the wanton loss of lives and livelihoods, almost every fabrics of the society are affected like the economy, transport, education, communication and commerce as well as trade.

In spite of the different realities created by the pandemic worldwide, one critical question still demand an answer and that is: what was the food security status of households during Covid-19 mitigation and restrictive measures in Nigeria and Cross River State in particular. More so, prices of food items and other consumables are reported to have sky-rocketed since the beginning of the Covid-19 pandemic, also, the likelihood of illness-related labor shortages in the food and agricultural sector, the break in transportation systems; isolation measures restricting market access as well as the disruption of the supply chain could lead to food loss and waste in addition to losses in the purchasing power thereby reducing the way and manner people eat thereby resulting to nutritional deficits (Rashul *et al.*, 2020. Hence, this study aimed at assessing how the United States Food Security Module could be used to measure household food insecurity during corona virus disease lockdown in Cross River State, to determine the coping-strategies adopted by households during the lockdown period and to compare the food security status of households in the three agricultural zones of the state.

MATERIALS AND METHODS

This study was conducted in Cross River State, one of the six states in South-South Nigeria. The study made use of primary data collected through the use of questionnaire from the three agricultural zones namely; Northern Agricultural zone, Central Agricultural zone and Southern Agricultural zone which took place between April and May 2020. From a list of registered farmers obtained from the Cross River Agricultural Development Programme (CRADP) headquarters, three hundred (300) farmers were randomly selected for the study, although only two hundred and forty (240) households filled and returned their questionnaire which was used as sample size. The six-item short form of the United State's Food Security Survey Module was applied to assess the food security status of farming households. Households' responses were scored from a total of 6 questions (each scored as '1' for affirmative response and '0' for negative response) and the total scores (range 0-6) were categorized into three (3) food security statuses: high or marginal food security (food secure) (0-1), low food security (2-4) and very low food security (5-6). In other words, streamlining the categorization into two gives: food secure from 0-1 and food insecure from 2-6.

RESULT AND DISCUSSIONS

Table1: Distribution of respondents by food security status in the zones and the state

Food security status	North **Percentage(80)**	Central **Percentage (80)**	South **Percentage (80)**	State **Percentage (240)**
Food secure	20 (25%)	25 (31.25%)	40 (50%)	85 (35.42%)
Low Food security	40 (50%)	45 (56.25%)	20 (25%)	105 (43.75%)
Very low food security	20 (25%)	10 (12.50%)	20 (25%)	50 (20.83%)
Total	**80 (100%)**	**80 (100%)**	**80 (100%)**	**240 (100%)**

Source: Field survey, 2020

The result of Table 1 shows that food secured households in the North was 25%, Central 31.25% and South 50% while food secured households in the entire state was 35.42%. On the other hands, low food security status was 50% in the North, 56.25% in the Central; 25% in the South and 43.75% in the state; whereas very low food security status was 25%, 12.50%; 25% and 20.83% across the Northern, Central and Southern agricultural zones and the state respectively. Therefore, in comparison, the Northern agricultural zone recorded the highest level of food insecure households of 75% which is higher than the entire state, followed by the Central zone with 68.75% and the Southern agricultural zone with 50%. The reason being that the Northern agricultural zone is the most rural of the entire zones and the least developed. The Central zone is more or less a border community with the Republic of Cameroun and as such boasts of some lively economic activities even though borders were shutdown while the Southern agricultural zone is an urban area and the administrative headquarters of the entire state, hence, several opportunities abound. In other words, only 35.42% of households were food secure during the coronavirus lockdown in the state while 64.58% of households were food insecure. This result is in agreement with the assertion by Rashul *et al.*, (2020) .

Table2: Distribution of respondents by coping strategies

Coping strategies	North **Freq/Percent**	Central **Freq/Percent**	South **Freq/Percent**	State **Freq/Percent**
Reducing amount of food consumed	30 (37.5%)	10 (12.5%)	5 (6.25%)	45 (18.75%)
Borrow money from family/friends	30 (37.5%)	20 (25.0%)	10 (12.5%)	60 (25.00%)
Acquire additional job	-	10 (12.5%)	40 (50.0%)	50 (20.83%)
Sold small assets	20 (25.0%)	30 (37.5%)	10 (12.5%)	60 (25.00%)
Migrated internally	-	10 (12.5%)	15(18.75%)	25 (10.42%)
Total	**80 (100%)**	**80 (100%)**	**80 (100%)**	**240 (100%)**

Source: Field survey, 2020

From Table 2 on coping strategies used by households during Covid-19 lockdown, it was clear that 37.5% in the North, 12.5% in the Central, 6.25% in the South and 18.75% in the state had to reduce the amount of food consumed by household members. This result may not be a surprise because the zone had the highest level of food insecure households and so to cope with the emergency situation; it became rational for households to reduce the amount of food consumed while the other zones thrives on minimal levels of food consumption confirming the studies of Rashul *et al.*, (2020). In a similar way, 37.5% in the North, 25% in the Central, 12.5% in the South and 25% in the State had to borrow money from family and friends in order to survive. Again, the higher level of food insecurity in the North warrants wanton borrowing from family and friends to make up for food shortages and less purchasing power while other zones borrowed moderately to survive. It was shown from Table 2 that no household in the North acquire additional job during the period, whereas 37.5% of households in the Central, 50% in the South and 29.17% in the State acquired additional jobs as coping strategies. Meanwhile, 25% of households in the North, 12.5% in the Central, 12.5% in the South and 16.67% in the State sold small assets to cope with the crisis. The Northern zone with high food insecurity sold much of her small assets especially land to carter for household member during the pandemic lockdown. On the other hands, 12.5% of households in the Central, 18.75% in the South and 10.42% in the State migrated internally during the lockdown period while no household from the North migrated. This result confirm results of earlier studies by (World Bank, (2020) Gardner *et al., (*2020); Lima *et al.*, (2020); Tanne *et al.*, (2020); & Mikhael *et al.*, (2020),

CONCLUSION AND RECOMMENDATION

Covid-19 pandemic has succeeded in disrupting the global food supply chain and the economy in 2020. The lockdown and restrictions has disrupted the value chains resulting in the abrupt falls in food supply and fiscal revenues and a sharp rise in commodity prices beyond the purchasing power of individual households. The state can cushion the impacts of corona virus disease by introducing measures such as massive investment in agricultural sector, social assistance benefits like conditional cash transfer to vulnerable farming households; tax relief for farmers; provision of agricultural inputs and employment retention/ unemployment benefits that will protect the vulnerable ones. Although, these measures might not contain the pandemic, the citizens should be encouraged to adhere strictly to the National Centre for Disease Control (NCDC) guidelines and protocols to reduce the spread of the virus and also assist in reducing food and nutrition insecurity as well as poverty.

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Percieved effect of post-harvest management practices on rural farmers livelihood in Kogi State of Nigeria

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ABSTRACT

This study assessed percieved effect of post-harvest management practices on rural farmers livelihood in Kogi State, Nigeria. Sample size of one hundred and sixty (160) rural farmers were selected with multi-stage sampling method. Structured questionnaire complimented with interview scheduled were used for data collection. Data collected were analyzed using descriptive statistics such as (frequency, percentages and mean) and inferential statistic (Kendall Coefficient of Concordance). The finding showed that 83.5% of farmers were males with mean age of 43 years. Improved income and livelihood of rural household ($\bar{X}$ =2.23) and make food available all through the years ($\bar{X}$ =2.14) were the major perceived effect of post-harvest management on farmer livelihood. The most constraints associated with post-harvest management in the study area were poor funding ($\bar{X}$ =7.74) and unfavorable price due to low income ($\bar{X}$ =8.05). It is recommended that credit and fund should be made available by governments and non-governmental organization so that farmers could easily purchase post-harvest tools and materials.

KEYWORDS: Post-harvest; Management-practices; Farmer; Livelihood

INTRODUCTION

Post-harvest can be defined as the stage of crop production immediately after harvesting. It involves stages such as drying, shelling, cleaning, sorting and packing (Vellema, 2008). Post-harvest management can be defined as methods or system applied to farmers' produce after harvesting purposely for preservation, conservation, quality control/enhancement, processing, packaging, storage, distribution, marketing, and utilization to meet the food and nutritional requirements of consumers and also to enhance their livelihood status. The roles of post-harvest management in agricultural production cannot be overemphasized, post-harvest management enhance agricultural production by reducing post-harvest losses to the bearest minimum, improves nutrition and livelihood status of farmers, adds value to agricultural products by opening new marketing opportunities, generating new jobs and enhance other related economic sectors for viable growth. Similarly, post-harvest management have ability to meet food requirement of the rural households by reducing avoidable losses. Post-harvest management also has the ability of transform rural areas economically thereby reducing the income disparities between urban and rural areas (Abeleira *et al.*, 2008). The objectives of the study are to describe the socioeconomic characteristic of farmers, examine perceived effects of post-harvest management practices on farmers livelihood and identify constraints associated with post-harvest management practices in the study area.

METHODOLOGY

Kogi State is located in the Guinea savannah ecological zone of Nigeria. The headquarters of the State is Lokoja, which is situated at the confluence of rivers Niger and Benue making the State to be popularly known as the confluence State. The State like any other State. The State is located between latitude 6^0 33' and 8^0 44'N and longitude 5^0 22' and 7^0 49'E. The major food crops grown in the State are yam, cassava, maize, sorghum, rice, millet, cowpea, pigeon pea, groundnut, bambaranut, cocoyam, sweet potato, beniseed, melon, banana, plantain and cotton. Fruits and leafy vegetables such as okra, pepper, fluted pumpkin and spinach are highly cultivated in the area. Tree crops grown in the State are: cashew, oil palm, citrus, cocoa, coffee and kolanut (Kogi State Ministry of Information Working Document, 2016). Multi-stage sampling technique was used for this study. The first stage involved random selection of three (3) Agricultural zones out of four (4) Agricultural zones in the State. The second stage involved the selection of one (1) Local Government Area (LGA) from each of the zones making a total number of three (3) LGAs. The third stage involved random selection of four (4) communities each from the selected LGAs making a total of twelve (12) villages. The fourth stage involved the random selection 10% of the farmers from the sampling frame.

Table1: Showing sample distribution of the farmers in the study area

State	Agricultural Zones	LGAs	Communities	Sampling Frame	Sample Size (10%)
Kogi State					
	Zone A	Yagba East	Alu	198	20
			Ponyan	172	17
			Ejuku	147	15
			Oranre	110	11
	Zone B	Dekina	Abocho	170	17
			Ayingba	100	10
			Egume	145	15
			Ojodu	123	12
	Zone C	Adavi	Aku	120	12
			Ateba	95	5
			Osara	82	8
			Ababo	75	8
Total	**3**	**3**	**12**	**1537**	**160**

Source: Agricultural development project in Kogi (2016)

Primary data was used for this study. Data were collected by the researcher assisted by trained enumerators using well-structured questionnaires. The objectives 1 and 2 of this study were achieved using descriptive statistics such as frequency distribution, percentage and mean.

Analytical Techniques

Perceived effect of post-harvest management on farmers livelihood measured using 3-points likert scale of Significant effect 3, Less effect 2, No effect 1. A mean score of 2.0 was obtained by adding 1+2+3=6 and dividing by 3. The decision rule was any mean $(\bar{X})$ scores > 2.0, indicates significant effect, while scores < 2.0 is termed no effect.

Kendall's Coefficient of Concordance

To examine the constraints associated with post-harvest management practices objective (iv), the Kendall's coefficient of concordance (*W*) adopted from Mohammed *et al.* (2018) was used to rank the problems. A lower mean rank indicates the problem is severe and vice versa. The Kendall's *W* was computed as shown below.

$$W = \frac{12\sum R^{-2}i - 3N(N-1)^2}{N\,(N-1)}$$

Where:

W = Kendall's value, *N* = total sample size, *R* = mean of the rank. The Kendall's coefficient of concordance (*W*) is a measure of the extent of agreement or disagreement among farmers of the rankings obtained. The value of *W* is positive and ranges from zero to one where one denotes perfect agreement among farmers of the rankings and zero denotes maximum disagreement.

RESULT AND DISCUSSION

Socioeconomic Characteristics of Farmers

Results in Table 2 showed that the mean age of the farmers in Kogi State was 43 years. This result revealed that farmers in the study area were still in their active and productive age. This may influence their readiness to try innovation, acquire new skills and knowledge on every aspects of post-harvest management which are expected to have positive effect on their income and livelihood. This finding is in consonance with that of Jabil and Abdul (2012) who stressed that younger farmers are more willing to adopt new techniques and knowledge than older ones. Results in Table 2 revealed that majority of the farmers (83.5%) in the study area were males. Male dominance might be due to difficult tasks involved in post-harvest management ranges from sorting, grading, packing, shelling, cleaning, processing, storage, processing, pests and diseases control.This finding agreed with Rashid *et al.* (2015), who revealed that men were more involved in traditional storage practices of yam in Ekiti State, Nigeria.Results in Table 2 indicated that the mean farming experience of the farmersin Kogi State was 29 years. The findings implied that farmers in the study area had long time experienced and are well exposed which might have equipped their knowledge and skills on post-harvest management which is expected to have positive effect on the livelihood. This findingis in agreement with that of Javed (2013),who reported that majority of farmers had high experience in post-harvest handling of vegetables. Results in Table 2 revealed that the mean years spent in formal education in Kogi State was 9 years, implying slow literacy considering the technical know-how required for proper sorting, grading, packaging, pest and diseases control. This could affect their eagerness to adopt post-harvest management and farmers livelihood. This agrees with Pelemo *et al.* (2019), who reported that bulk of rural farming families in Kogi State, Nigeria had low literacy level.

Table 2: Distribution of the farmers according to socio-economic characteristics (n=160)

Variables	Frequency	Percentage
Age (year)		
≤30	34	21.2
31-40	33	20.6
41-50	57	35.6
51-60	28	17.5
>60	8	5.1
Mean	**43**	

Sex		
Male	132	82.5
Female	28	17.5
Experience in Farming (year)		
1-10	17	10.6
11-20	29	18.1
21-30	40	25.0
31-40	41	25.6
>40	33	20.7
Mean	**28.9**	
Years spent in formal education		
1-6	45	30.8
6-12	63	43.2
>12	38	26.1
Mean	**9**	

Source: Field survey, 2018

Percieved effect of post-harvest management on farmers livelihood

Table 3 revealed that improved income and livelihood of rural households ($\bar{X}$ =2.23) ranked 1st, this implies that post-harvest management increase income and livelihood of farmers in the study area. The findings agreed with Anyawu *et al.* (2017), who revealed that the most noticeable effect of adoption of a given technology is increased income and livelihood of the adopters. This was followed by making food available throughout the year ($\bar{X}$ =2.14) ranked 2nd. It is believed that adoption of post-harvest management coupled with proper training will make food available throughout the year, thereby reducing the problem associated with food insecurity. Table 3 further revealed that increase in shelf-life of farmers' produce ($\bar{X}$ =2.10), assist in market information ($\bar{X}$ =2.07) and improved in non-farm expenditure ($\bar{X}$ =2.07) were ranked 3rd and 4th respectively.

Table 3: Percieved effect of post-harvest management practices on farmers livelihood (n=160)

Variables	Mean ($\bar{x}$)	R	D
Improved income and livelihood of rural household	2.23	1st	SE
Increase in shelf-life of agricultural produce	2.10	3rd	SE
Make food available all through the years	2.14	2nd	SE
Assist in market information	2.07	4th	SE
Increase productive assets	2.05	8th	SE
Maintaining quality of farm produce	2.04	9th	SE
Improved non-farm expenditure	2.07	4th	SE
Assist in the procurement of households assets	2.06	7th	SE
Enhance livelihood expenditure	2.07	4th	SE
Settlement of children school fees	2.04	9th	SE
Enhance off-farm activities	2.01	11th	SE
Provision of employment opportunities	1.92	12th	NE

Source: Field survey, 2018

Note: SE=Significant effect, NE=No effect

Constraints Associated with Post-harvest Management Practices

The result in Table 4 showed that Kendall's coefficient of concordance obtained in the analysis was 0. 21% level of probability. This shows a weak on the outcome of ranking. Table 4 showed that nineteen constraints were identified as key problems faced by farmers in the adoption of post-harvest management. The results revealed shortage of fund ($\bar{X}$ =7.74) ranked 1st as the most serious constraint faced by farmers. This was followed by unfavorable price due to low income problem inadequate credit with mean value of ($\bar{X}$ =8.05) and inadequate credit ($\bar{X}$ =8.47) ranked 2nd and 3rd respectively. This finding is supported by Maxwell (2014) showed that shortage of fund and inadequate access to credit were the most serious constraints affecting rice farmers in Sub-Sahara Africa.

Table 4: Distribution according to constraints associated with post-harvest management (n=160)

Variables	Mean ($\bar{x}$)	Ranking
Inadequate credit facilities	8.47	3rd
Poor funding	7.74	1st
High cost of post-harvest materials	8.52	4th
Unfavorable price due to low income	8.05	2nd
Loss in market value	9.20	6th
Lack of farmers participations	10.54	14th
Insect attacks	9.41	7th
Inadequate market information	10.25	13th
Disease attack	9.09	5th
Transportation challenge	9.42	8th
Inadequate technical knowledge	9.65	9th
Knowledge and skills limitation	10.7	12th
Inadequate infrastructure	9.94	11th
Limited knowledge on post-harvest management	9.65	9th
Kendall's W	0.21	
Chi-Squared	316.324	
Degree	15	
Asymptotic significant	0.000***	

Source: Field survey, 2018

CONCLUSION AND RECOMMENDATIONS

It can be concluded that majority of the farmers were male in their active age with low literacy level. Improved income and livelihood of rural household and make food available all through the years were the major perceived of post-harvest management practices on farmers livelihood. The major constraints associated with post-harvest technologies were poor funding and inadequate credit facilities. It is recommended that credit and fund should be made available by governments and non-governmental organization so that farmers' could purchase post-harvest tools needed to enhance value addition to agricultural produce.

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Determinants of participation of irish potato farmers of the women-in-agriculture and youth empowerment (waye) programme in plateau state, nigeria.

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ABSTRACT

Irish potato production in Nigeria has become a pathway in attaining sustainable food security and agricultural development amidst climate change, covid-19 pandemic and general insecurity., This study examined the factors influencing the level of participation of irish potato farmers of the women-in-agriculture and youth empowerment (WAYE) programme in plateau state, Nigeria. A multi-stage sampling method was employed to select 256 respondents. Data were collected through the use of questionnaires and were subjected to both descriptive and inferential statistics. The results of the analysis showed that the mean farming experience was 10 and 16 years for participating and non-participating farmers, while mean farm size for participating farmers and non- participating farmers were 1.4 and 0.5 ha, respectfully. The result findings reveal that, (55%) and (47%) of the participating farmers and non-participating farmers respectively had secondary school education, which constituted the highest level of educational qualification attained in the study area. Factors influencing the level of participation of irish potato farmers in (WAYE)programme in Plateau State are marital status (3.72, P<0.01), sex (2.25, P<0.05), years of irish potatoes production (9.85, P<0.01), household size (10.92, P< 0.01), awareness of WAYE programme (4.93, P< 0.01), a unit increase in these factors will subsequently influence the level of participation of irish potato farmers in (WAYEP) programme. It was recommended that, Government and Non-Governmental Organizations (NGOs) should create more awareness, provide credit, farm inputs at a subsidized rate and, rural markets should be linked to the urban market through extension agent and media to attract good value for food crops thereby enhancing living standard of the farmers.

Keywords: Factors influencing, level of participation, irish potatoes, WAYE, Plateau State.

INTRODUCTION

Irish potato (*Solanum tubersun*) belongs to the solanaceae family. The (*Solanum tubersun*) is a native of western hemisphere and is believed to have originated somewhere between Mexico and Chile possibly in Andes highlands of Bolivia and Peru. It later spread to other places like England and Ireland where it is predominantly cultivated Irish potato was introduced into Nigeria in the later part of the 19th century and early 20th century by Europeans notably the Tin miners in the Jos Plateau (Mado, 2013). It has a high nutritive value and it is grown for food purposes as well as livestock feed. It is also used for industrial purposes (Okeowo, 1999; Burton, 2000. Irish potato is therefore an important crop not only as food crop, but also its social, economic and environmental relationships with the people who grow, sell and consume it (Alimba and Mgbada, 2003). The empowerment of women and youths that are involved in potato production in Plateau State is therefore crucial to poverty reduction. Women-in-Agriculture and Youth Empowerment (WAYE) programme aims at encouraging Irish potato production through participation of the target group as a strategy to combat rural poverty. Therefore, Women-In-Agriculture Programme (WIA) and Youth-In-Agriculture Programme (YIAP) were both initiated and implemented towards reducing poverty, improvement on the income and raising the level of living of rural dwellers to achieve the first goal of the MDGs (Sharma, 2004)

A number of studies have been carried out by different scholars (Shittu, 2012; Kotter and Petras, 2012; Mado, 2013; Shittu and Panan, 2014) to assess the Women-In-Agriculture and Youth Empowerment (WAYE) programme. Their focus, however, was on women and men and only few Local Government Areas were covered, thus limiting the scope on WAYE programme objectives. Similarly, Ifenkwe (2015), in his study on the impact of WAYE programme, concentrated his efforts more on reproductive health (HIV/AIDS and rehabilitation) while the agricultural component and other aspects of the programme were greatly ignored. What is almost lacking in these studies, however, is any direct involvement of youth in the programme and assessment of impact of the programme on the livelihood of the participating farmers. Therefore, their studies have left a knowledge gap on impact of Women-In-Agriculture and Youth Empowerment programme objectives. It is based on this, that the study made an attempt to find solutions to the following research specific objectives: describes the socio-economic characteristics of irish potato farmers in the study area; determine the socio-economic characteristics and factors influencing the level of participation of irish potato farmers in the programme;

METHODOLOGY

This study was conducted in Plateau State, Nigeria. The State was created in 1976 from the defunct Benue-Plateau State. The name “Plateau State” was derived from the State’s spectacular geographical landscape, with the high lands rising from 1,200 meters above sea level at the low lands to a peak of 1,829 meters above sea level. It is located in Nigeria’s middle belt and lies between latitude $80.24^0\,N$ and longitudes $80.32^0\,E$ and $100.38^0\,E$ ofthe Greenwich Meridian. The State is situated in the tropical zone, with a higher altitude ranges from 12 meters, about 400 feet to a peak of 1829 meters above sea level (Plateau Agricultural Development Programme, 2000). Plateau State has a boundary with Bauchi State to the north-east and Kaduna State to the north-west. It is also bounded to the south-east and south-west by Taraba and Nasarawa States, respectively. The State has a landmass covering nearly 53,585 square kilometers with a population of 3,577, 669 people as per 2006 census (NPC, 2006).

A multi-stage sampling procedure was used to select participating farmers for the study. There are nine (9) irish potatoes producing LGAs in Plateau State and they are given a priority consideration for the programme. In the first stage, all these nine Local Government Areas were used for the study. This was because of their high level of production of potatoes in State. In

the second stage, two villages were randomly selected in each Local Government Area and this was based on the level of participation in the programme as well as in potato production. This gave a total of eighteen (18) villages. During a reconnaissance survey of the study area in 2016, the list of WAYE potato farmers in the chosen villages was compiled with the help of the programme coordinating officers in each LGA and the total number obtained was seven hundred and eleven (711) farmers. Therefore, a total number of two hundred and fifty-six (256) Irish potato farmers were selected randomly using the random number table method.
Both primary data and secondary information was used for the study. The primary data were obtained by the use of well-structured questionnaire and administered to the participating farmers and non-participating farmers by the researcher and to be assisted by well-trained enumerators from the Plateau State Agricultural Development Project (PADPs). The secondary information was obtained as base-line information from WAYE head office and the coordinating liaison offices. Also, information from other related studies were used to support the discussion of results of the findings. Data were analyzed using both descriptive and inferential statistics. Descriptive statistics was used to achieve objectives (i)), while inferential statistics (Tobit model) was used to achieve objective (ii).

RESULTS AND DISCUSSION

Socio-economic Characteristics of Participating and Non-Participating Farmers

The results in Table 1 shows that the mean age of the participating farmers was 38 years while that of the non-participating farmers was 43 years. This means that the participating farmers were younger in age than the non-participating farmers. This is in line with the major objective of WAYE programme to engage both young men and women in agricultural activities with the aim of improving the living conditions of households in the study area. Age has been found to be an important variable in agricultural productivity; hence both categories of the farmers were within the agricultural productive age range of 30-50 years quoted by Food and Agriculture Organization (FAO, 2000; 2008). About 65% and 60% of the participating farmers were married and single while (66%) and (17%) of the non-participating farmers were also married and single respectively. The significance of marital status on agricultural production can be best explained in terms of the supply of family labour (Adewale, 2005).

The result of the study shows, that (67%) and (33%) of the participating farmers were males and females while (77%) and (33%) of the non-participating farmers were males and females respectively. This agrees with the findings of Ayandiji and Adeniyi (2011) who reported that males have dominance potato production activities unlike their female's counterparts because agricultural activities are regarded as labour intensive. The result in Table 1 indicated that majority (63%) of the participating farmers cultivated between 1-1.5ha for Irish potato production while (75%) of non-participating farmers used less than 1ha.This mean farm size cultivated by both categories of farmers was 1.4 ha and 0.5ha respectively. According to Adamu (2019) classification of farm size of 0.1 - 5.9 hectares as small farms implies in this study that all the farmers were small scale farmers. This may be due to the inheritance system of land ownership practiced in the study area which results in land fragmentation among farmers, leading to small farm holdings. The implication of small farm size affects the quantities of Irish potato output produced which in turn affect both the income and food security status of the farmers. The result agrees with the finding of (Nwosu, 2007) who reported that majority (82%) of the farmers acquired the farmland through renting with farm sizes ranging from 0.5-4 hetares. Farming experience in Irish potato, the result in Table 1 indicated that, (67%) and (54%) of both the participating farmers and non-participating farmers had Irish potato farming experience between 1-10 years and 11-20years respectively. Abonge (2012) opined that farming experience is an important factor in determining both the productivity and the production level in farming. The result in Table 1 reveals that (55%) and (47%) of the participating farmers and non-participating farmers had secondary school education, which constituted the largest number of educational qualification attained in the study area. Adewale (2005) had identified literacy among other factors as a variable that positively influenced the use of improved agricultural inputs by farmers. According to the distribution of respondents in Table 5.1. The result shows that majority (77%) and (73%) of the participating and non-participating farmers have a family size of 1-10 members respectively. This finding agrees with that of Ifenkwe (2012) reported that the average family size in Africa is between 8 and 9 people in a household. The implication of large number in a household can be a motivation to the adoption of innovations because members will provide the required family labour for Irish potato production. This will reduce the cost of production.

Table 1: Distribution of respondents according to age, marital status, Gender, farm size, farm experience, educational level and household size.

	Participating farmers		**Non – participating farmers**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Age(Yrs)				
20 – 30	17	6.64	8	3.13
31 – 40	173	67.57	96	37.50
41 – 50	56	21.88	118	46.09
51 – 60	8	3.13	23	8.98
61 – 70	2	0.78	11	4.30
Total	**256**	**100**	**256**	**100**
Mean	38		43	
Marital status				
Single	60	23.44	43	16.80
Married	166	64.84	169	67.58
Divorced	8	3.13	11	4.30
Widow	22	8.59	33	12.89
Total	**256**		**256**	**100**
Gender				
Male	171	66.80	196	76.56
Female	85	33.20	60	23.44
Total	**256**	**100**	**256**	**100**
Farm size(ha)				
Less than 1	36	14.06	192	75.2
1 – 1.5	162	63.28	35	13.68
1.6 – 2.5	47	18.36	21	8.20
2.6 – 3.5	8	3.13	7	2.73
3.6 and above	3	1.17	1	0.37
Total	**256**	**100**	**256**	**100**
Mean	1.4		0.5	
Farming exp(yrs)				
1 – 10	172	67.19	72	28.13
11 – 20	64	25.00	138	53.91
21 – 30	14	5.46	26	10.16
31 – 40	5	1.95	14	5.46
41 – 50	1	0.40	6	2.34

Total	**256**	**100**	**256**	**100**
Mean	10		16	
Educational level				
No education	10	3.91	6	2.34
Qur'anic/adult.	7	2.73	11	4.30
Primary	71	27.73	88	34.38
Secondary	141	55.08	120	46.88
Tertiary	27	10.55	31	12.10
Total	**256**	**100**	**256**	**100**
Household size				
1 – 10	198	77.34	187	73.05
11 – 20	55	21.48	64	25.00
21 – 30	3	1.18	5	1.95
Total	**256**	**100**	**256**	**100**
Mean	**8**		**8**	

Source: Field Survey, 2017

Tobit analysis examines factors influencing level of participation in WAYE in Plateau State. The results in Table 5 indicates that, commutatively about 17.6% of the variation in level of participation is explained by the variable included in the model. It shows that marital status, years in irish potatoes production, household size, awareness of WAYEP were found to significantly influenced the level of participation at 1%, level of probability whereas only sex, is found significantly influence the level of participation at P<0.05. The implication of this finding is that, the level of participation increases by variation in marital status thus as farmers' marital status changes from single to married, the level of participation equally increases from 1 to 27.6%. It was also observed that as years in Irish potatoes production increase by 1unit, the level of participation increases by 34.7%. Thus more experience farmers tend to participate more than new in-experienced farmers. So also as household size increase by 1 person the level of participation increase by 78%. Nonetheless as level of awareness of the existence of WAYE programme increases by 1 the level of participation is equally increases by 30%. Based on these findings marital status, sex, years in irish potatoe production, household size, and awareness are the major factors influencing farmers' participation in WAYEP. Adamu (2021), factors influencing women farmers'-participation in Development Exchange Centre (DEC) microcredit programme of Kaduna State, Nigeria; shows that level of education (1%), age (1%), house size (5%), credit (10%), farm experience (10%), extension (5%) and years of involvement in cooperative society (5%) were significantly related with level of participation in (DEC) microcredit programme.

Table 5: Estimates Factors influencing farmers' level of participation in WAYE

Variables	Coefficients	Std.Err.	T-value	P>|t|
Livelihood index	0.2763	0.1769	1.56	0.119
Age	14.4942	0.9059	12.82	16.388
Marital status	0.6472***	0.1738	3.72***	0.000
Sex	1.1465**	0.5099	2.25**	0.025
Farm size	0.1742	0.3384	0.51	0.607
Years in iris potatoes production	0.3474***	0.0353	9.85***	0.000
Household Size	0.7805***	0.0715	10.92***	0.000
Credited amount	0.0000	0.0000	0.13	0.897

Profit	0.0000	0.0000	-1.59	0.112
Perception	-0.7914	0.7003	-1.13	0.259
Awareness of wayep	3.0301***	0.6150	4.93***	0.000
_cons	21.2049	3.5333	6***	0.000

Source: Field Survey, 2017 *** P< 0.01, ** P<0.05 and * P<0.10

CONCLUSION AND RECOMMENDATION

Based on the findings, the study concludes that marital status, sex, years in irish potatoe production, household size, and awareness are the major factors influencing farmers' participation in WAYEP programme. It was recommended that, Government and Non-Governmental Organizations (NGOs) should create more awareness, provide credit, farm inputs a subsidized rate and, rural markets should be linked to the urban market through appropriate information channels such as extension agent and media to attract good value for food crops thereby enhancing living standard of the farmers especially those in the rural area.

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Determinants of food insecurity status among farming households in Abeokuta Agricultural Zone, Ogun State, Nigeria

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ABSTRACT

The study examined food insecurity status among farming households in Abeokuta Agricultural zone, Ogun State, Nigeria. Data were collected from 120 farming households with the aid of questionnaire using multistage sampling techniques. Coping strategy index (CSI) and ordered probit regression analysis were employed for data analysis. Results of the CSI revealed that, only 17.5% of the farming households were food secure while majority (82.5%) of the farming households were food insecure. In terms of the status of food insecurity, most (33.3%) of the food insecure households were moderately food insure, 26.7% were severely food insecure. and 22.5% were mildly food insecure in the study area. Age of household heads, education, marital status, household size, number of dependents, farm size, income, extension contacts, off-farm occupation, non-food expenses and membership of cooperative society were the significant determinants of food insecurity status in the study area. Therefore, policies that encourage youth participation in farming activities, increase educational level, farm size, income, extension contact and cooperative membership should be put in place to reduce food insecurity in the study area.

Keywords: Determinants, food insecurity status, farming households, ordered probit

INTRODUCTION

Food insecurity is the inconsistent access to nutritionally adequate and safe food (Food and Agricultural OrganisationFAO, 2006; Mendy, Asongwe, and Nkongho 2020). The United State Department of Agriculture in 2018 describes food insecurity as a “situation in which regular access to adequate food is limited by lack of money and other necessary resources”. According to World Food Programme (WFP, 2012), half of the world’s hungry are from smallholder farming communities, living on marginal lands that are vulnerable to the effects of climate change, despite smallholder farmers producing nearly 90% of the continent’s total food output in Africa (Ojuederie and Ogunsola, 2017). In 2014, the Federal Ministry of Agriculture of Nigeria estimated that 65% of the population is food insecure despite having majority of all employments dependent on agriculture (Ogunpaimo,Oyetunde-Usman and Surajudeen 2021). FAO (2022) reported that about 19.4 million people will face food crisis between June and August, 2022 in Nigeria. According to the report, food crisis will affect 21 states and FCT including, 416,000 Internally Displayed Persons (IDPs). The report identified insecurity especially insurgency in the North-east and North-central states, climate change, high inflation in soaring food commodity prices, reduction in household income due to the long-term effect of COVID-19 pandemic and displacement arising from conflict and armed banditry as factors that will contribute to the hunger crisis.

Recent study by Ibukun and Adebayo (2021) reported that only 12% of the households in Nigeria were food secure, 5% were mildly food insecure and 24% were moderately food insecure while majority of the households (58%) experienced severe food insecurity during the COVID -19 pandemic. Their result from the ordered probit regression identified education, income and wealth status as the main determinants of food security in the country.
Attaining and sustaining food security for all of humanity seems to be an overwhelming global challenge in the face of population growth, environmental degradation and accelerating climate change. Against this backdrop, this study seeks to examine the determinants of food insecurity status among farming households in the study area. The specific objectives were to determine the food insecurity status of the farming households and analyse the factors influencing food insecurity status of the farming households in the study area.

METHODOLOGY

Study Area: The study was carried out in Ogun State, Nigeria. Ogun State is a state in southwestern Nigeria, created in February 3, 1976. Abeokuta is its headquarters. It is bounded in the west by Republic of Benin, south by Lagos State and the Atlantic Ocean, east by Ondo State and in the North by Oyo and Osun States. Ogun State is located on longitude 3^0 35^1 00^{11}E and latitude 7^0 00^1 00^{11}N, and covers approximately an area of 16,980.55 square kilometers and a population of 5,217700,140 people (NBS, 2019). The major food crop grown in the study area include, among others, cassava, yam, cocoyam, plantain, maize and vegetable while cocoa is the major permanent crop. The natural vegetation in the study area is rain forest.

Sampling Procedure and Data Collection: Multistage sampling technique was used to select 120 respondents for the study. The first stage involved the purposive selection of Abeokuta Agricultural zone from the four Agricultural zones in the state. The second stage involved the purposive selection of two Local Government Areas from the zone because of the predominance of farming activities in the areas. In the third stage, simple random sampling technique was used to select 2 communities from each of the LGAs making a total of 4 communities. The fourth stage involved random selection of 30 farming households from each of the selected communities making a total of 120 farming households for the study. Data on socioeconomic and food insecurity characteristics of the selected households were collected with the aid of pre-tested questionnaire and focus group discussion.

Analytical Techniques: Coping Strategy Index (CSI): The CARE International/World Food Programme Household Coping Strategy Index (CSI) was used to measure food insecurity status and identified coping strategies adopted by the farming households. The CSI index was calculated by multiplying the frequency and consensus severity of using a set of eleven coping strategies against food shortage related shocks. The consensus ranking of coping strategies was determined using a focus group discussion. The higher the score the higher the probability of a household level of food insecurity (Maxwell Watkins, Wheeler and Collins (2003); Hussein, Segun and Hassan (2016); Ojo Akin-Olagunju, Yusuf and Yusuf, (2019))

Ordered Probit Regression Model: This was used to assess the factors that influence the food insecurity status of the farming households based on the results of the CSI scores. Following Hussein *et al.,* (2016), the food insecurity status is grouped and ranked based on the level of the CSI score into four ordered values (j = 0, 1, 2, 3). However, these observed values are assumed to derive from some unobservable latent variable Yi*, which is expressed as:

$Yi = Xi\beta + \varepsilon i$ (1)

Yi is the hypothesised predicators of food insecurity, βs is a vector of parameters to be estimated, and ε is an error term which is assumed to be normally distributed (Greene, 2003). The values for the observed variable Yi are assumed to be related to the latent variable Yi* in the following manner: $Y = 0$ = food secure if $Y^* < \mu$ o where $\mu = 0$; $Y = 1$ = less food insecure if $0 \leq Y^* < \mu 1$; $Y = 2$ = moderately food insecure if $\mu 1 \leq Y^* < \mu 2$; $Y = 3$ = severely food insecure if $\mu 2 \leq Y^* < \mu 3$; μ means the unknown threshold parameters. The CSI rank represents the dependent variable; Xi's are the independent variables which include: X_1= Age of household head (years); X_2 = Education (years); X_3 = Marital status (married=1, otherwise=0); X_4= Household size (number of persons); X_5 =Size of dependents (number of persons); X_6 = Farm size (ha); X_7 = Income (₦); X_8 = Access to extension services (dummy), X_9 = Off-farm occupation (dummy); X_{10} =Non-food expenses (dummy); X_{11} = membership of cooperative association (dummy).

RESULTS AND DISCUSSION

Food insecurity status among farming households in the study area

Result in Table 1 reveals that majority (82.5%) of the farming households were food insecure. In terms of the status of food insecurity, a larger proportion (33.3%)of the food insecure households were moderately food insure followed by the severely (26.7%) and mildly (22.5%) food insecure households respectively. Only 17.5% of the farming households were food secure in the study area. This is an indication that food insecurity situation of the farming households was hazardous. According to FAO (2008) and Sileshi, Kadigi, Mutabazi and Sieber, (2019), these households may need special attention in terms of direct food assistance and access to productive resources in form of subsidy which will enable them to improve their productive capacity and help them escape from food insecurity in the near future. This result agrees with the findings of Ayoade and Adetunbi (2013) that food insecurity was about65% among farming households in south western Nigeria. In the same vein, Hussein *et al.,* (2016) reported that only 27% of the households in Katsina State were food secure, 44% were mildly food insecure 17% were moderately food insecure while 12% experienced severe food insecurity. Ibukun and Adebayo (2021) also observed that 58% of the households in Nigeria were severely food insecure during the COVID -19 pandemic.

Table 1: Food insecurity status among farming households in the study area

Ordered value	Food insecurity status	CSI range	Frequency	Percentage
F = 0	Food secure	0	21	17.5
F = 1	Mildly food insecure	1-15	27	22.5
F = 2	Moderately food insecure	16-30	40	33.3
F = 3	Severely food insecure	>30	32	26.7

Source: Field Survey, 2022

Determinants of food insecurity status (FIS) among farming households in the study area

Result of the ordered probit model on determinants of food insecurity status among the farming households in the study area is presented in Table 2. The overall model is highly significant (p<0.01) with log likelihood of -125.272 implying that the model provides a good fit for the data. The estimated cut-off points (μ) satisfy the conditions that μ1 < μ2 < μ3. This implies that these categories are ranked in an ordered way. The first cut-off point (Y=0 for "food secure group") was used as a mark for the purpose of comparison. Only the significant variables are presented in the table and marginal effects are used for explanation since estimated coefficients from an ordered logit model are difficult to interpret because they are in log-odds units. The result reveals that age of the household heads had a negative significant relationship with FIS in the mildly FIS group and positive significant relationship with moderately FIS group at 5% alpha levels. This implies that a unit increase in the age of the household heads decreases the probability of farming households being mildly food insecure while it increases the probability of being moderately food insecure in the study area. This result agrees with the report of Opiyo, Wasonga and Nyagito (2014) that older farmers are relatively less productive in farming communities and thus more susceptible to caprice of economic distress. Education was negative and significant with moderately FIS group. The implies that as the level of education of the household increases by one year, the likelihood of being moderately food insecure decreases by 8.2% in the study area. This is in tandem with the findings of Ogunniyi, Omotoso, Salman, Omotayo, Olagunju and Aremu (2021) that higher level of educational attainment provides higher levels of welfare such as food security for the households. Marital status of the household heads negatively influences the probability of households being mildly ($p<0.05$) food insecure. This implies that households headed by married farmers are less likely to be mildly food insecure in the study area. Result on the household size reveals that an additional person to the household will increase the tendency of being moderately food insecure by 3.3% and being severely food insecure by 8.1%.

Table 2: Determinants of food insecurity status among the farming households

Variables	Coefficients	Marginal effects		
		Mildly	Moderately	Severely
Age	0.011** (0.132)	-0.003** (0.023)	0.014** (0.019)	-0.026 (0.022)
Education	0.175** (0.752)	0.067 (0.191)	-0.082** (0.171)	0.343 (0.187)
Marital status	0.202* (0.410)	-0.480** (0.422)	-0.042 (0.118)	0.062 (0.128)
Household size	0.210** (2.231)	-0.092 (0.105)	0.033* (0.083)	0.081** (0.113)
Dependents	-0.326** (0.044)	0.125 (0.019)	0.521** (0.041)	0.660** (0.039)
Farm size	0.174*** (1.195)	0.861*** (0.385)	-0.077** (0.336)	-0.412 (0.413)
Income	0.000*** (0.001)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000 (0.000)
Extension contact	0.266* (0.610)	0.148 (0.480)	-0.058 (0.409)	-0.645* (0.466)
Off-farm occupation	-0.116** (0.112)	0.014** (0.288)	-0.141** (0.249)	-0.293** (0.283)
Non-food expenses	-0.222** (0.072)	0.492* (0.543)	0.412 (0.416)	0.149** (0.044)
Cooperative	-0.862** (0.71)	-0.720 (0.014)	-0.600 (0.499)	-0.049* (0.054)
Cut 1	-2.096676			
Cut 2	-2.142646			
No of observation	120			
Log likelihood	-125.272			
LR Chi^2 (14)	26.22			
Pseudo R^2	0.3755			

****, **, * =significant at 1%, 5%, 10%* *Figures in parenthesis are standard error*

Source: Computed from Field Survey, 2022

Also, the size of dependents positively influences the probability of being moderately and severely susceptible to food insecurity at 5% alpha levels respectively in the study area. This implies that the probability of being moderately or severely food insecure increases with the size of dependents in the study area. This result concurs with the report of Ojo *et al.,* (2019) that larger proportion of household resources are directed to dependants who contribute little or nothing towards household welfare leading to food insecurity. The coefficient of farm size positively influences the likelihood of households being mildly food insecure ($p<0.01$) and negatively influences the probability of being moderately food insecure ($p<0.05$). This implies that a unit increase in farm size will increase the probability of households becoming mildly food insecure while it decreases the probability of becoming moderately food insecure in the study area. This negative relationship is similar to the findings of Johnson and Awoseyila (2020) that increase in farm size reduces vulnerability to food insecurity in Ondo state. Monthly income ($p<0.01$) of the households had an inverse significant relationship with mildly and moderately food insecure category. This implies that as the monthly income increases, the likelihood of households being mildly and moderately food insecure decreases in the study area. This result is in agreement with Akukwe (2020) that income is a significant factor in reducing food insecurity. The probability of households becoming severely food insecure decreases with extension contact at 5% alpha levels. This is because access to extension officers exposes the farmers to innovation and good agricultural practices which could increase their output and reduce food insecurity. Furthermore, engagement in off-farm occupation will cause 1.4% increase in probability of the household being mildly vulnerable, 14.1% and 29.3%decrease in the probability of the household being moderately and severely food insecure in the study area. Moreover, a unit increase in non-food expenses was found to increase the tendency of households becoming both mildly and severely food insecure at 10% and 5% alpha levels respectively. This is in concordance with the findings of Ojo *et al.*, (2019) that spending on non-food items reduces the amount of resources available to combat food insecurity. Finally, membership of cooperative society had an inverse relationship with severely food insecure category. This implies that farming household heads who are members of cooperative society are less likely to be severely food insecure in the study area.

CONCLUSION

The study investigated food insecurity status and its determinants among farming households in Abeokuta Agricultural zone, Ogun State. Findings revealed that the farming households were found to be fairly distributed across the food insecurity statuses in the study area. While a larger proportion of the households were moderately food insecure, others were either severely or mildly food insecure. Based on the findings, the study recommends that policies that encourages youth participation in farming activities, increase educational level, farm size, income, Extension contact and cooperative membership should be put in place to reduce food insecurity in the study area.

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The Impact of the National Fadama III Project on Farmers's Income in Ezza North Local Government Area of Ebonyi State, Nigeria.

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ABSTRACT:

One Hundred and fifty (150) participating household in Fadama III project and fifty (50) non-participating households were randomly selected for this study. Data were collected by well-structural and pre-tested questionnaire and analyzed through the use of descriptive and inferential statistical tools. The Double-Different (DD) Estimator was used to compare changes in outcome measures. Findings revealed that the average of respondents was 50 years, while 53.33% and 60% respectively were males. About 52% and 56% respectively were married; with 20.67% and 16% possessing no formal education respectively. 86.67% of the respondents have household sizes ranging from 5-12 members. The average per capita income of the Fadama III user households before project implementation was ₦126,000; while that of the Fadama III non-beneficiaries was ₦127,665. On the average, the real income of Fadama III beneficiaries increased from₦126,000-₦175,000; as a result of participation in the project. By contrast however, average real income of Fadama III non-beneficiaries increased from ₦127,665 –₦163,000. The mean increase in income for participants in Fadama III was significantly different at 1% level. It is therefore recommended that appropriate policy to ensure proper education of rural populace be advocated.

INTRODUCTION:

Nigeria is a country blessed with potentially good and water resources required for sustainable agricultural development. It is a known fact that many government agricultural intervention development programmes in Nigeria have not had lasting impact on agricultural development and many have not yielded the expected results of sustained increase in food production (Omonona, 2009). Agricultural methods have remained undeveloped, despite many years of efforts on technology generation and transfer in Nigeria.

The agricultural sector is not just only the most important non-oil economic activity in Nigeria, but also the single largest employer of labour force (about 70% according to NBS, 2007). Thus, the agricultural sector is often seen as very important in reducing poverty (Agenor et al, 2004). Agriculture and rural development in Nigeria has been neglected for long. However, actions to address the cause of rural poverty often represent the key components of this rural sector strategy (Nwajiuba, 2013). Usually, there is absence of infrastructures (such as water, electricity, and motor able roads) which improve the quality of life. The rural areas are saddled with low purchasing power. Indeed, the ongoing neglect of rural areas continues to widen the gaps between the rural and urban areas with regards to the levels of social and economic opportunities, physical development and available infrastructural facilities (Olayiwola and Adeleye, 2005). In addition, rural financial support are scarce and most rural finance policies implemented previously have hindered, rather than assisted in improving agricultural production (Simonyan and Omolehin, 2012).

However, in an attempt to alleviate poverty among the rural Nigerians and also to increase the incomes and productivity of the rural inhabitants, an approach of meeting up with millennium development goals (MDGs) of food sufficiency and poverty eradication; the Federal Government of Nigeria embarked on several projects aimed at improving the income and productivity of the small-scale rural farmers. These projects have not substantially generated increased income or improve the standard of living of the rural poor farmers in Nigeria. It is to be noted that since independence, the Federal Government of Nigeria in conjunction with the United Nations and other developed agencies, initiated Agriculture Economic Devolvement related projects for the farmers of which the National Fadama Development Programme is one. Its main focus being to finance the development of Fadama lands by introducing small-scale irrigation schemes in states, with Fadama development potentials (Yunana et al, 2013). This was the first phase of the project which was subsequently followed by the second phase:- called Fadama II.

Fadama II implemented an innovative Local Development Planning (LDP) tool and building on the success of the community-Driven Development mechanisms initiated in the first Fadama project. Subsequently, following the success recorded in Fadama II project, the World Bank in conjunction with the Federal Government introduced the Fadama III project. Fadama III is a tripartite funded intervention by the World Bank (1996), the Federal Government of Nigeria and participating states with objectives targeted towards poverty reduction.

Fadama II project came fully into operation from 2009-2013 as a follow-up to the Fadama II project which was assessed to have impacted on the lives of the rural farmers, raising their incomes by 63%. This project just like Fadama II took the Community Driven Development Approach which places beneficiaries in the driver’s seat where local community members under the umbrella of Fadama Community Associations (FCA) and Fadama Users Groups (FUGs)to oversee the design and implementation of the project and are empowered through skills and capacity building to improve their livelihoods by increasing income generating activities.

Fadama III project established standardized procedures and steps to guide the local people on how to take part in the decision making process. It established platforms for participation, such as local consultations meetings to indentify and select the needed infrastructure to be funded by the project. Beneficiaries (participants) were trained to identify the needed infrastructure, execute and manage small-scale development projects in their communities. Community people, through the FUGs and the FCAs were designed to be the executing agencies of local development projects. Capacity building activities were conducted to ensure that they have the ability to manage the different aspects of the project implementation; including financial management, procurement, management and quality control at a level acceptable to the project. Therefore, this study assesses the impact of Fadama III project on the income of beneficiary farmers in Ezza North Local Government Area of Ebonyi State. Specifically, the study described the socio-economic characteristics of Fadama III beneficiaries and non-beneficiaries groups; ascertained the income level of the participants and non-participants before and after intervention programme, determined the effects of socio-economic characteristics of the

Fadama III, Users on their income and, identify the constraints associated with the FADAMA III farming beneficiaries of the project.

METHODOLOGY:

Study Area:

The Study was carried out in Ezza North Local Government Area of Ebonyi State, Nigeria. It lies between latitudes $5^0 41$ and $6^0 45$ North of the equator, and longitude $7^0 31$ and $7^0 43$ East of the Greenish Meridian. It has headquarter at Ebiaji and it is one of the thirteen local Government Area that makes up Ebonyi State.

It has a annual rainfall range of between 1800mm-2000mm, and an annual temperature range of between 28^0-32^0C; and with a relative humidity of 65%. It has a population of 145,619 persons and a land area of $305km^2$;most of which are fertile (NPC, 2006). The main seasons experienced in the area are dry season which starts from April –October, with a short break normally in the month of August, called “August break”. It is inhabitants are mostly farmers, and the common crops grown include maize, groundnut, plantain, banana, cassava, fruits and vegetables. Other economic activities engaged in are artisans, hunting, fishing, vulcanizing, tailoring, fashion and designing, etc.

Sampling Procedure:

A multi-stage random sampling technique was used to select communities, villages and the respondents in Ezza North Local Government Area of Ebonyi State. Firstly, five (5) communities were randomly selected from the fourteen (14) communities that make up the study area; secondly, three (3) villages were also randomly selected from each community already chosen in stage 1. This gave a total of 15 villages. In Stage III, ten (10) households were randomly selected from each village chosen in stage II. This gave a total of one hundred and fifty (150) participating households. In addition, ten (10) non-participating households were randomly selected from each of the communities chosen in stage I; thereby giving a total of fifty (50) non-participating households that were used for the study.

Analytical Techniques:

The data generated were analyzed using descriptive and inferential statistical tools. The descriptive tools used were means, percentages and frequency distribution tables. This was used for objectives (i) and (iv).

Model Specification:

The Double-Difference (Difference in-Difference) Method:

The Double-difference analytical tool is a quantitative method often used to estimate and compare change in outcome, both pre and post program for participants and non-participants (Chen et, al, 2006). In order to use the estimation in question, there must be information on both participants and non-participants, and all individuals must be observed, both before and after the programme (Verner and Verner, 2006). The Double-Difference method which is also known as Difference-in-Difference Method (Duflo et al, 2004), has the formula:-

$$DD = (Yp_i - Yp_0) - (YnP_1 - YnP_0)$$

Where:

Yp_1= Outcome (i.e income) of beneficiaries after the project started.

Yp_o = Outcome of beneficiaries before the project started

Ynp_1 = Outcome of non- beneficiaries after project started;

Ynp_o = Outcome of non-beneficiaries before the project started.

The advantage of the Double-Difference Estimator is that it nets out the effects of any additive factors (whether observable or unobservable) that have fixed impacts on the outcome indicator (such as the abilities of the farmers, or the inherent quality of natural resources) or that reflects common trends affecting project participants and non-participants equally, such as changes in prices or whether (Ravallion, 2005).

In principle, the Double-Difference Approach can be used to assess project impacts without using any other statistical tools (such as the propensity Score Matching (PSM) method as applied by (Philip et al, 2009) as it will produce unbiased estimates of impact, as long as these assumptions hold, hence the adoption of this method in this study for estimating the project impact among the Fadama III beneficiaries in Ezza North Local Government Area of Ebonyi State, Nigeria.

Multiple Regression Model:

This was used to determine the effects of socio-economic characteristics of the FADAMA III users on their income. Linear, semi-log, double-log and exponential functional forms were employed, fitted and tried, and on the basis of economic theory, statistical and econometric criteria; linear functional form was chosen as the lead equation.. The explicit form of the model is presented below:

$Y= b_0tb_1X_1tb_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6+b_7x_7\ldots\ldots b_nx_n+e$

Where:

Y= income of beneficiaries are non-beneficiaries before and after the project.

X_1= Age of the participants and non-participants in years

X_2 = Gender of the participants and non- participants in (male = 1, otherwise = 0)

X_3 = Marital status of the participants and non-participants (married = 1; otherwise = 0)

X_4 = Educational attainment in years

X_5 = Household size in numbers

X_6 = Farm size in hectares

X_7 = Extension contact (contact =1; otherwise =0)

X_8 = Fadama III access (Access = 1, otherwise =0)

b_0 = Constant term

b_i-b_8 = Coefficients to be estimated ei= Error term

RESULTS AND DISCUSSION:

Socio-economic characteristics of respondents

	Benefiting Households		Non – Benefiting Households	
Variables	Frequency	Percentage (%)	Frequency	Percentage
Age in Years:				
21-30	28	18.67	8	16.00
31-40	65	43.33	25	50.00
41-50	35	23.33	12	24.00
51-60	22	14.67	5	10.00
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**
Gender:				
Male	80	53.33	30	60.00
Female	70	46.67	20	40.00
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**
Marital Status:				
Single	51	34.00	12	24.00
Married	78	52.00	28	56.00
Widow(er)	12	8.00	6	12.00
Divorced/ Separated	9	6.00	4	8.00
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**
Educational Level/Years:				
No formal education	31	20.67	12	24.00
Primary education	48	32.67	28	56.00
Secondary education	40	26.67	6	12.00
Tertiary education	30	20.00	4	8.00
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**

Household size:					
1-5	45	30.00	25	50.00	
6-10	55	36.67	12	24.00	
11-1530		20.00	8	16.00	
16-20	20	13.33	5	10.00	
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**	
Extension Contact:					
Contact		90	60.00	35	70.~~00~~
Non-Contact	60	40.00	15	56.~~00~~	
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**	
Farm Size (Ha):					
01-0.5	36	24	28	56.00	
0.6-1.0	45	30	12	24.00	
1.1-1.5	36	24	6	12.00	
1.6-2.0	33	22	4	8.00	
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**	
Fadama III Access:					
Fadama Acess		100	66.67	32	64.00
Non-Fadama Access	50	33.33	18	36.00	
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**	

Source: Computed from the field survey data, 2020.

Analysis of the socio-economic variables of the respondents (Table 1) showed that majority (43.33%) and (50%) of both the Fadama III beneficiaries and Non-beneficiaries were still in their youths. This portends that the youths were much involved in Fadama III project in the study area. This dominance of the middle-aged people in the programme is in accordance with the work of Agwu and Edun (2007) in Ilaro Agriculture zone of Ogun State, Nigeria. Of the 200 households that were involved in the study 80 and 30 of them were males; while 70 and 20 were females. This indicated dominance of male folks in Fadama III project activities in the area studied. A close look at Table I also revealed that 20.67% of the beneficiaries and 16% of non-beneficiaries of the Fadama III project had no formal education. This has great implication on the implementation of the Fadama III project as it might be seen as mere embodiment of paper works. It is also a known fact the education is a key factor in reduction of rural poverty in general; whether the households are headed by men or women (Ike, 2012). Girei et al (2013) also are of the opinion that education has been a factor in the adoption of modern technology innovations.

Large household sizes have been noted to have correlation with food insecurity and poverty; especially when the household head is engaged in agriculture as the main source of livelihood and income (Ike and Uzokwe, 2011). Hence, there is need for efforts to further sensitization of the populace on the need to control births and all cultural beliefs that tend to lead to over-population should be removed through proper advocacy.

Most of the respondents (52% and 56%) of the participating and non-participating households in the Fadama III project are married. This dominance by married people had earlier been reported by (Ike 2012).

The same Table 1 equally revealed that participant and non-participant used some of the provisions of Fadama III project to expand their farm sizes and this agress with the findings of Olaolu et al, (2012).

Table 2(a): Income level of Respondent Households before the inception of Fadama III project.

	Fadama III Beneficiaries		Non – Fadama III Beneficiaries	
Level of Income (₦)	**Frequency**	**Percentage (%)**	**Frequency**	**Percentages (%)**
1,000-50,000	40	26.67	18	36.00
51,000-100,000	35	23.33	15	30.00
101,000-150,000	30	20.00	10	20.00
151,000-200,000	25	16.67	7	14.00
201,000-250,000	15	10.00	_	_
251,000-300,000	5	3.33	_	_
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**

Source: Computed from the field survey data, 2020

Table 2b: Income level of Respondent Households after the inception of Fadama III project.

Level of Income (₦)	Frequency	Percentage (%)	Frequency	Percentages (%)
1,000-50,000	45	30.00	20	40.00
51,000-100,000	38	25.33	16	32.00
101,000-150,000	32	21.33	12	24.00

151,000-200,000 4.00		20	13.33	2
201,000-250,000		10	6.67	_ _
251,000-300,000	5	3.33	_	_
Total	**150**	**100.~~00~~**	**50**	**100.~~00~~**

Source: Computed from the field survey data, 2020.

Considering the income beneficiaries before and after the inception of Fadama III project (Table 2a and Table 2b) about 38.89%/27.68% of the beneficiaries increased their income at least 10% in the first year of Fadama III operations in the area. This finding is the tandem with that of Yunana et al, (2013) who established the fact that Fadama III project had a positive impact on income and wealth of participants in FCT, and also Iwala (2014) found a positive economic impact of Fadama III in small scale community – owned infrastructure on beneficiaries in Ondo State, Nigeria.

The result of the estimated parameters on the effects of socio-economic characteristic of FADAMA III users on their income is presented in Table 3. Of the four functional forms that were fitted and tried with the production function model, the linear functional form was chosen as the lead equation based on the established economic theory.

Table 3: Regression Estimate of the Effects of Socio-economic characteristic of the FADAMA III users on their income.

Variables	Linear (+)	Exponential	Cobb-Douglas	Semi-log
Constant	-0.0289	-0.1734	0.1591	0.8725
	(-0.03) (0.45)	(1.13)	(1.13)	
Age	0.158	0.0639	0.1463	(0.3921)
	(0.95) (0.83)	(0.67)	(0.82	
Gender	0.3849 0.2148	0.2339	0.4226	
	(1.11)	(1.34)	(1.44)	(1.19)
Marital	0.2407 0.944	0.727	0.1995	
Status	(0.60) (0.51)	(0.39)	(0.49)	
Education	0.3832 0.0958	0.1986	0.3956	
	(3.71)***	(1.19)	(1.14)	(2.21)*
Household	0.3469 0.1321	0.2664	0.7076	
Size	(1.95)*(1.60)	(1.41)	(1.72)*	
Farm size	0.3603 0.0597	0.1099	0.2705	

	(2.70)**	(0.68)	(0.54)	(0.60)
Extension	0.3369 0.1312	0.1559	0.3978	
Contact	(2.55)**	(0.85)	(0.99)	(2.78)**
Fadama III	0.6476 -0.0959	-0.1036	-0.2737	
Access	(3.11)***	(0.69)	(0.74)	(0.89)
R^2	0.5127 0.2297	0.2812	0.4677	
R^{-2}	0.4779 0.0787	0.1973	0.3241	
F-ratio	3.08***	1.52	1.25	1.86

Source: Computed from the field survey day, 2020

*;** and *** simply implies significant at 10%5% and 1% level respectively.

The coefficients for education, household sizes, farm size, extension contact and Fadama III Access had direct relationship with the Fadama III users income. However, they were all significant at varied probability levels. In fact, these were all expected and are in accordance with a priori expectations.

Table 4: Constraints associated with the Fadama III farming beneficiaries of the project.

Constraints	Frequency	Percentage	Ranking
Inadequate improved seeds	90	60.00	2nd
High cost and unavailability of farm inputs e.g. fertilizers and agro-chemicals	95	63.33	1st
Clashes with pastorialist	52	34.67	10th
Political and economic instability	68	45.33	6th
Dishonesty and corruption among the Fadama officials	65	43.33	7th
Untimely disbursement of farm inputs	85	56.67	3rd
Pests and diseases infestation	45	30.00	11th
Inadequate power supply	58	38.67	9th
Poor communication network	60	40.00	8th
Unstable government politics	36	24.00	12th
Poor access to extension services	75	50.00	5th
Poor supporting infrastructure	80	53.33	4th

Source: Computed from the field survey data, 2020.
Multiple responses

Table 4 showcased the main constraints highlighted by the Fadama III beneficiaries in the study area. The average percentage of each constraint across the study area were computed and ranked in the Table. Those factors are shown in Table 4 with average constraints above 50% were the major challenges that needed to be addressed. The remaining problems that scores less than 50% were regarded as minor or non-effective challenges in the execution of FADAMA III Project.

The high cost and unavailability of farm inputs such as agrochemicals and fertilizers in Nigeria; especially the inorganic fertilizers are variously reported among literatures (IRRI, 2015; Ume et al, 2018; Udemezue, 2019) could be correlated to the removal of "Fertilizer Subsidy Programme" by the Federal Government; thereby exposing the farmers to procure this all important resource from the black market to the detriment of their farm profits.

CONCLUSION:

It has been established that Fadama III project impacted positively on the income of project participants. However, it is a known fact that Ebonyi State did not participate Fadama III project, and so the only control group applicable here is the Non- Fadama III communities; not receiving support from the Fadama III project. The study recommends that the project should entrench proper measures towards ensuring proper education of the rural populace.

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Comparison Analysis of Gender Participation in Fish Production in Ikorodu Local Government Lagos State, Nigeria

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ABSTRACT

The study assessed the comparison analysis of gender participation in fish production in Ikorodu local government Lagos state, Nigeria. Purposive simple random sampling technique was used to select the fish farmers through well-structured questionnaires. Both descriptive and inferential statistics were used to analyze the data collected. Result show that catfish farming were male dominated (male=96%, female =40%) mostly married, educated, young with large household size. The result of the Liker scale revealed that 97% of the male fish farmers participated in fish pre-production and production activities, while only 1.47% of the female fish farmers sometimes participated. But 95% of the female fish farmers participated in both processing and marketing activities while less than 30% of male fish farmers sometimes participated. Both male and female fish farmers faced with various challenges but more than 90% of the female fish farmers faced the problem of poor water supply especially during the dry season follow by inadequate capital and high rate of fish mortality when compare to male counterpart. In view of the above findings the study recommends that fish farm inputs like feeds, fingerings and credit facilities should be made available and affordable to both genders on time to enhance improved production. Female fish farmers should be trained on fish management to reduce high rate of fish mortality.
Key words: Gender participation, catfish farming, female fish farmers, male fish farmers, high fish mortality rate

INTRODUCTION

Fish farming, a branch of aquaculture is defined as the raising, cultivation, propagation and marketing of fish such as catfish, tilapia and ornamental fish for food security, income generation and livelihood activity (Umunna, 2020). Fish farming provides important services including supporting nutritional wellbeing, provide feed stocks for the industrial sector, increasing export opportunities, employment opportunity suitable for male and female gender in the society (Dagtekin *et*, *al.*, 2007).

Gender concerns in the fishery sector involve the roles and responsibilities assume to male and female as well as their level of participation in fish farming activities (Adam *et*, *al.*, 2021).

While men participate mostly in activities such as selection and supplying of fingerlings and other inputs (fish feeds, drugs), pond construction and liming, stocking and Weighing of fish, women participate mostly in fish feeding, processors, and marketing activities (Adeoye *et, al.*, 2020). Women participation in fish production activities cannot be over emphasized. Subasinghe *et, a*l., (2021) claim that despite women major role in fish farming production as well as their involvement in small-scale fisheries value chains, yet most women lack information on fish farming, lack access to capital and access to land and this has limited their participation. Thus, this study aims to comparatively analyze the gender participation in fish production in Ikorodu local government Lagos State, Nigeria.

RESEARCH METHODOLOGY

This study was carried out in Ikorodu Local Government area of Lagos state, Nigeria. The respondents for the study were catfish farmers in the Fish Farm Estate Ikorodu. The State is very rich in different forms of aquatic ecological zones that support different varieties of fish species and aquatic organisms; thereby providing productive fishing opportunities for fishers (Adesoji and Kerere, 2013). A two stage sampling techniques was employed in this study. First stage involved purposive selection of Ikorodu Local Government area for the study. This is because of the predominant fish farming activities in the area. Second stage involves random selection of 140 fish farmers from the list of registered fish farmers in the Fish Farm Estate Ikorodu area. These were stratified into male and female fish farmers. Therefore, a total number of 136 copies of duly completed questionnaire were collected of which 96 of the fish farmers were males and 40 were females. And these were used for the final analysis. This accounts for a true representation of the population since they do not have equal numbers of farmers in the area. Information elicited from the respondents are socio-economic characteristics (age, educational status, household size, marital status, years of fish farming experience etc), participation levels in the production activities and constraints encountered in fish farming among others. Both descriptive and inferential statistics were used to analyze the data collected. Participation level was captured with Likert-Type Scale using 3 points comprising of always, sometimes and rarely.

RESULT AND DISCUSSION:

The result of the socio-economic characteristics, as presented in table 1, indicates that majority of the fish farmers were males (70.59%) with only 29.41% female this shows that fish farming activities are gender sensitive.This implies that men are more involved in fish farming than the female counterpart which might be attributed to the common believe that fish farming activities are energy-sapping and time-consuming nature in which women may not be able to go through the rigor. The result is in agreement with the findings of Ajala *et, al.,* (2017). Majority of fish farmers were young and energetic and in their productive age with the average age of 42 years across the data. This was similar to Siyanbola *et, al.*, (2020) that fish farmers were still young, agile and could easily adapt to new techniques that could enhance their productivity. It was also revealed that 80.21% and 77.5% of the male and female fish farmers respectively were married. Furthermore, male fish farmers have higher literacy level when compared with the female fish farmers. While 54.16% of the male fish farmers had secondary education only 37.5% of the female had. This was in line with Siyanbola *et, al.,* (2020) that male fish farmers were more educated than female counterparts in Lagos state, Nigeria. The average household size for the male fish farmer was 6 while that of the female fish farmer is 5. More than 60% of the fish farmers had household size between 4-6 persons. The result is similar to the findings of Adebesin (2011) that most fish farmers usually have large family size. In addition, the average fish farming experience for both gender were 13 years which implies that majority of the fish farmers have been in fishery operation for a long time. Afodu *et,al.*, (2016) reported that the higher the years of farming experience of a farmers the higher the level of his productivity and efficiency. This implies that fish farming production in the area has a greater potential to be continued, sustained and expand in scope and reap scale economies in the future.

Table 1: Description of the socio-economic characteristics of the respondents

	Male (96)		Female (40)		Pooled data (136)	
Variables	Frequency	Percentages	Frequency	Percentages	Frequency	Percentages
Age						
< =30	22	22.92	11	27.50	33	24.26
31-50	48	50.00	22	55.00	70	51.47
51-70	23	23.96	6	15.00	29	21.32
71 and above	3	3.13	1	2.50	4.0	2.94
Mean	43(14)		41(13.6)		42 (13.8)	
Educational						
No formal	10	10.42	9	22.50	15	11.03
Primary	20	20.83	10	25.0	20	14.71
Secondary	52	54.16	15	37.50	85	62.50
Adult	8	8.33	2	5.0	10	7.35
Tertiary	5	5.21	4	10.0	6	4.41
Marital status						
Single	17	17.71	7	17.50	24	17.65
Married	77	80.21	31	77.50	108	79.41
Widowed	2	2.08	2	5.00	4	2.95
Household size						
<=3	19	19.79	10	25.00	29	21.32
4-6	44	45.83	20	50.00	64	47.06
7-9	25	26.04	6	15.00	31	22.79
10 and above	8	8.33	4	10.00	12	8.82
Mean	6		5		6	
Fishing Exp						

<15	69	71.88	27	67.50	96	70.59
16-30	23	23.96	11	27.50	34	25.00
31-45	1	1.04	1	2.50	2	1.47
45 and above	3	3.13	1	2.50	4	2.94
Mean	13		13		13	

Source: field survey, 2022

Table 2 shows the comparative analysis of gender participation in different fish farming activities in the study area. These activities were classified into four groups such as pre-production, production, processing and marketing. Under the pre-production activities, it was revealed that male gender had highest participation level in almost the activities except for feed formulation activities. Male gender also had the highest participation level in production activities except the fish feeding activities in which female gender sometime participated.

Furthermore, female gender had the highest participation level on processing activities except the weighing of fish in which most women were rarely participated. It was also revealed that female gender had the highest participation level in marketing activities while many of the male gender rarely participated in the marketing activities in the study area. This shows that female fish farmers participated in the important aspect (marketing)of the production. This implies that female fish farmers participated more than male counterpart in financial aspect of fish farming.

Table 2: Level of gender participation at different activities of fish farming production

Activities	Gender Participation level					
	Male (%)			**Female (%)**		
	Always	**Sometimes**	**Rarely**	**Always**	**Sometimes**	**Rarely**
Pre-production activities						
Selection of fish	96.32	3.68	-	1.47	1.47	97.06
Pond Construction	99.26	0.74	-	1.47	1.47	97.06
Purchasing inputs	98.53	1.47	-	2.21	0.74	97.06
Capital sourcing	100	-	-	1.47	1.47	97.06
Feed Formulation	2.21	74.0	23.79	67.80	1.47	30.73
Production activities						
Feeding of fish	97.79	1.47	0.74	2.21	97.79	-
Stocking of fish	98.53	1.47	-	0.74	13.97	85.29
Treating of fish	97.79	1.47	0.74	1.47	10.29	88.24
weeding of pond	98.53	1.47	-	1.47	0.74	97.79
Harvesting of fish	98.53	1.47	-	1.47	0.74	97.79
Processing of fish						
Weighing of fish	97.79	2.21	-	1.48	12.59	85.93
Smoking of fish	30.53	21.47	48.00	71.48	0.74	27.78
Salting of fish	44.85	25.15	30.00	91.48	0.74	7.78
Drying of fish	26.67	3.85	69.48	97.48	0.74	1.78
Storage of fish	68.53	1.47	30.00	81.48	9.74	8.78

Marketing of fish						
Wholesaling	20.47	10.58	68.95	95.59	4.41	-
Retailing	2.21	5.15	92.65	95.59	4.41	-
Exporting	26.67	3.85	69.48	95.59	4.41	-

Table 3 revealed that both gender in the study area were faced with various challenges ranges from inadequate capital (92.71%), Poor water supply during dry season (92.18%), Poor marketing system (91.97%), High cost of labour (91.71%) and High fish mortality rate (90.44%). Higher percentage of the female fish farmers faced the problem of poor water supply especially during the dry season follow by inadequate capital, inadequate credit/loan, and high rate of fish mortality and high cost of labour. This implies that female fish farmers were at less advantage in production. This result is in agreement with Abdul *et,al.,* (2017) that women were found to face many of problems while participation in fish farming activities.

Table 3: Constrain to gender participation in fish farming

Constraints	Male (%)	Female (%)	Pooled (%)
	Percentage	Percentage	Percentage
High cost of fingerlings	83.33	82.50	83.09
Inadequate credit/loan	85.42	90.50	86.76
Poor marketing	89.58	87.50	91.97
Inadequate capital	90.63	91.30	92.71
High fish mortality rate	90.63	90.44	90.44
Insufficient Land/space	82.29	90.00	84.56
Poor water supply during dry season	85.00	94.50	92.18
Poor fish health service	71.88	82.50	75.00
Insufficient information on fish farming	75.00	80.00	76.47
High cost of feed	85.42	75.00	75.00
High cost of labour	89.59	90.41	91.71

Source: field survey, 2022

CONCLUSION AND RECOMMENDATIONS

The findings of this study show that catfish farming is male dominated activities which imply that fish farming activities are gender sensitive. Majority were married, educated, and were in their active age which also implies that fish farming production in the area has a great potential to be continued, sustained and expand in scope and reap scale economies in the future. It is clear that male fish farmers participated mostly in fish pre-production and production activities, while female always participated in marketing activities, this implies that female participated mostly in financial aspect of fish production. Both male and female fish farmers faced with various challenges but higher percentage of the female fish farmers faced the problem of poor water supply follow by inadequate capital, high mortality rate more than the male counterpart which implies that female fish farmers were at less advantage in production. The study recommends that fish farm inputs like feeds, fingerings should be made available and affordable to both genders on time to enhance improved production. Female fish farmers should be trained on fish management to reduce high fish mortality rate. Also Government should provide grants and credit access most especially to female fish farmers as incentives to expand their scope of operations and encourage better female participation in catfish farming production in Nigeria. Owing to the fact that majority of the female participated more in the financial aspect of fish production, they should be involved in policy formulation and decision-making relevant to catfish production in Nigeria.

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Factors Constraining Rural Womens' Adoption of Cocoyam Value Added Innovations in Abia State, Nigeria

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ABSTRACT

This paper examines the major factors constraining the adoption of cocoyam value added innovations among rural women in Abia State, Nigeria. Multistage sampling techniques were used in selecting 120 rural women for the study. Descriptive statistics was used for data analysis while Ordinary Least Squares regression model was used to test the hypothesis. The results showed that majority (78% and 56%) of the women were aware of cocoyam soup thickener and cocoyam flour respectively. However, only 48% of them were aware of cocoyam chips. There was low level (2.18) of adoption of cocoyam value added innovations among the women. Factors constraining the adoption of cocoyam value added innovations as revealed by the study include lack of fund, insufficient knowledge of practices, lack of equipment and lack of follow-up training. Furthermore, the study showed that there was a significant relationship between identified constraints and adoption at 5% (2.39**) level of significance. These findings suggest that there is an urgent need for researchers, policy makers and administrators of the extension service to consider these constraints seriously so as to overcome them to increase the adoption of cocoyam value added innovations among women in Abia state.

Keywords: Cocoyam value added innovations, Rural women, Adoption, Constraints

INTRODUCTION

In Nigeria, cocoyam is used to describe both taro (*Colocasia esculenta*) and tannia (*Xanthosoma sagitifolum*). Cocoyam is a perennial crop cultivated as annuals, for mostly their edible starchy storage underground stems called corms and cormels (Igbozulike, 2015). It is an economic crop that is not only used as food but also as an agro-industrial raw material in pharmaceutical, confectionery, and livestock industries (Kundu *et al*., 2012).

With around 2.86 metric tonnes produced in 2019 (FAOSTAT, 2021), Nigeria is the world's top producer of cocoyam, making up more than 27% of global production (FAOSTAT, 2021). After yam and cassava, it is the third most significant root and tuber crop grown and consumed in Nigeria (NRCRI, 2015). Cocoyam, which belongs to the Araceae family, is one of the six most significant root and tuber crops in the world (Ekanem and Osuji, 2006).

Cocoyam is rich in digestive starch, good quality protein, vitamin C, thiamine, riboflavin, niacin and high content of protein and essential amino acids (Lewu et al., 2009). It can be processed into flour, cake, crisp, and chip (Chukwu *et al*. 2012; Enwelu *et al*., 2014). The flour can be used for soups, biscuits, bread and puddings. The peels can also be used as feed for ruminants (Apata and Babalola, 2012). It has low glycemic index which is why it is highly recommended for diabetics. In terms of nutrition, it is better than most crops because of its digestibility, crude protein content and essential minerals like Calcium, Magnesium and Phosphorous (Green, 2003).

Value addition boosts production, decreases spoilage in storage, and expands the categories of consumers who consume agricultural products (Chukwu et al, 2015). The preference for the production and consumption of other crops, which has resulted in its neglect and under-utilization, is one of the main factors affecting value addition in cocoyam (Utomakili and Agunbiade (2013). In addition, Okorji et al. (2013) asserted that good processing, preservation, and value addition technologies are out of the reach of rural women, which hinders effective value addition to cocoyam. Furthermore, cocoyam is a bulky and, perishable commodity that is exceedingly expensive to transport without any initial processing and value addition (Aniedu and Aniedu, 2015).

As a result, National Root Crops Research Institute (NRCRI), Umudike, which has the national mandate to undertake research into root and tuber crops, has developed several value-added (processing) technologies of root and tuber crops in an effort to reduce their perishability and add value to these crops. Products like cocoyam flour and snacks have been developed and widely disseminated to women's groups around the country. This paper therefore sought to investigate the level of adoption and factors constraining the adoption of cocoyam value added innovations among rural women in Abia State, Nigeria. The study specifically examined the following objectives: ascertain rural women's awareness of cocoyam value added innovations; assess rural women's level of adoption of cocoyam value added innovations in the state; and identify the factors constraining rural women’s’ adoption of cocoyam value added innovations in the state.

METHODOLOGY

This study was conducted in Abia State, Nigeria. The state is situated between latitudes 5°06'60" north of the equator and 7°21'59.99" east of the Greenwich Meridian. The participants in the study were rural women who had received training in cassava value addition from the National Root Crops Research Institute, Umudike in the state. The study adopted a multistage random sampling technique in the selection of respondents. Two agricultural zones from the State were purposefully chosen in the first stage. Two Local Government Areas (L.G.As) from each of the agricultural zones were purposefully sampled in the second stage. The reason for purposive selection is because root and tuber crops' value added innovations have been enormously disseminated in the agricultural zones and LGAs. A list of rural women beneficiaries from each of the selected LGAs was collected from the institute's Women-in-Agriculture Unit. As a result, samples of two women groups were randomly chosen in each of the chosen LGAs, creating a sampling frame for the rural women beneficiaries that resulted in a total of 1200 women beneficiaries. In the last stage, 60 women (10% of the recipients) were randomly selected from each LGA. This gave a sample size of 120 rural women. Structured questionnaire was administered to elicit data from the women. Information was gathered through the internet and various reports that were pertinent to the study. Data were analyzed using descriptive statistics such as percentages, means and inferential statistics like OLS regression model. The level of adoption of cocoyam value added innovations was measured using 4-point adoption score model.

The following scaling point was adopted; Never (1), Sometimes (2), Often (3), Always (4). The mean score was 2.50. The level of adoption was categorized as follows; 3.5 – 4.0 = Very High; 2.5 – 3.0 = High; < 2.5 = Low

Factors constraining adoption of cocoyam value added innovations was measured using 3-point type Likert scale: Not serious (1), Serious (2), and Very serious (3). The mean score was 2.00. To determine the relationship between identified constraints and adoption of cocoyam value-added innovations, Ordinary Least Squares regression was adopted.
Y = Level of Adoption of cocoyam value-added innovations (measured with mean point of the 4-point adoption scale). The independent variables were factors constraining adoption of cocoyam value added innovations (measured with mean point of the 3-point type Likert scale). X1 =Lack of ready market; X2 = Lack of fund; X3=Insufficient knowledge of the practices; X4=Lack of equipments/facilities; X5 = Lack of follow-up training; X6 = Lack of extension contact; X7 = Busy with other activities and thus have no time for processing; e = Error term.

RESULTS AND DISCUSSION

1. Awareness of Cocoyam Value Added Innovations

Table 1 shows distribution of rural women according to their awareness of cocoyam value added innovations. The table reveals that 48.3%, 77.5% and 55.8% of the respondents were aware of cocoyam chips, cocoyam soup thickener and cocoyam flour**.**

Table 1: Distribution of rural women according to their awareness of cocoyam value added innovations

	Innovation	Aware		Unaware	
		Frequency	**Percentage**	**Frequency**	**Percentage**
1	Cocoyam chips	58	48.3	62	51.7
2	Cocoyam soup thickener	93	77.5	27	22.5
3	Cocoyam flour	67	55.8	53	44.2

Source: Field survey, 2021

Except for cocoyam chips, majority of the respondents were aware of cocoyam value added innovations in the State. Awareness of a new technology is a pre-requisite for adoption of the technology. It enables farmers to learn the existence of a technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of.

2. Level of Adoption of Cocoyam Value Added Innovations by Rural Women

Table 2 shows level of adoption of cocoyam value added innovations by rural women in Abia State, Nigeria**.** According to table 2, the respondents had low level of adoption of cocoyam value-added innovations (χ=2.18).

Table 2: Level of adoption of cocoyam value added innovations in Abia State

	Innovation	Always	Often	Sometimes	Never	Total	Mean	Remark
1	Cocoyam chips	18 (72)	9 (27)	39 (78)	54 (54)	231	1.93	Low
2	Cocoyam soup thickener	41 (164)	8 (24)	45 (90)	26 (26)	304	2.53	High
3	Cocoyam flour	23 (92)	12 (36)	38 (76)	47 (47)	251	2.09	Low
	Grand mean						**2.18**	**Low**

Source: Field survey, 2021

Respondents had low level of utilization of cocoyam chips and cocoyam flour but high level of utilization of cocoyam soup thickener. This could be attributed to the fact that Abia State is not a major cocoyam producing in Nigeria.

3. Factors constraining adoption of cocoyam value added innovations

The result on table 3 revealed that the respondents agreed that four out of the eight constraints mentioned in the table seriously affected adoption of cocoyam value-added innovations in the Abia State.

Table 3: Constraints to adoption of cocoyam value-added innovations

	Constraint	Very serious	Serious	Not serious	Total	Mean	Remark
1	Lack of ready market	12 (36)	31 (62)	77 (77)	175	1.46	Not Serious
2	Lack of fund	37 (111)	52 (104)	31 (31)	246	2.05	Serious
3	Insufficient knowledge of the practices	61 (183)	43 (86)	16 (16)	285	2.38	Serious
4	Lack of equipments/facilities	44 (132)	46 (92)	30 (30)	254	2.12	Serious
5	Lack of follow-up training	60 (180)	35 (70)	25 (25)	275	2.29	Serious
6	Lack of extension contact	16 (48)	31 (62)	73 (73)	183	1.53	Not serious
7	Busy with other activities and thus have no time for processing	24 (72)	57 (114)	39 (39)	225	1.88	Not serious
8	Lack of interest	6 (18)	26 (52)	88 (88)	158	1.32	Not serious

Source: Field survey, 2021

Constraints such as lack of funds (χ=2.05), insufficient knowledge of practices (χ=2.38), lack of equipment/facilities (χ=2.12) and lack of follow-up training (χ=2.29) were the major constraints to adoption of cocoyam value added innovations in the State.

4. Effect of Identified Constraints on Adoption of Cocoyam Value Added Innovations

Table 4 showed multiple regression estimates of the relationship between identified constraints and adoption of cocoyam value added innovations among rural women in the Abia State, Nigeria. The four functional forms were fitted in the regression model and based on some econometric criterion, such as the number and level of the significant variables and their conformity to *a priori* expectation, the lead equation was chosen.

Table 4: Regression estimate of the relationship between identified constraints and adoption of cocoyam value added innovations by the rural women

Variables	Linear	Semi-log	Double Log +	Exponential
Constant	1.532 (3.79)***	.359 (1.87)*	.573 (5.08)***	1.981 (8.36)***
Lack of ready market	.132 (0.66)	.009 (0.10)	-.003 (-0.02)	.198 (0.60)
Lack of fund	-.281 (2.01)**	-.146 (2.20)**	-.273 (2.30)**	-.524 (2.10)**
Insufficient knowledge of the practices	.051 (0.28)	.051 (0.60)	.136 (0.86)	.178 (0.53)
Lack of equipments/facilities	.125 (0.92)	.078 (1.21)	.138 (1.17)	.237 (0.96)
Lack of follow-up training	-.230 (-1.34)	-.133 (-1.63)*	-.277 (-1.86)*	-.492 (-1.58)*
Lack of extension contact	-.070 (-0.40)	.014 (0.17)	.077 (0.53)	-.025 (-0.08)
Busy with other activities and thus have no time for processing	-.208 (-1.18)	-.123 (-1.47)	-.248 (-1.73)*	-.435 (-1.45)
Lack of interest	-.395 (1.81)*	-.182 (1.74)*	-.276 (1.64)*	-.607 (1.71)*
F-statistics	2.71**	2.37**	2.39**	2.70**

R^2	0.3632	0.3460	0.3470	0.3629

The Double-log function was chosen as the lead equation. The R^2 value was 0.363 indicating that 35% of the variation in the adoption of cocoyam value added innovations was accounted for by the explanatory variables expressed in the models. The F-ratio was significant at 5% level indicating the goodness of fit of the model used in the analysis..

The coefficients of lack of fund, lack of follow-up training, busy with other activities and lack of interest were significant at 5%, 10%, 10% and 10% levels of probability respectively and inversely related with adoption of cocoyam value added innovations. This implies that lack of fund, lack of follow-up training, busy with other activities and lack of interest significantly impeded the adoption of cocoyam value added innovations in the state. These findings suggest that there is an urgent need for researchers, policy makers and administrators of the extension service to consider these constraints seriously so as to overcome them to increase the adoption of cocoyam value added innovations among women in Abia state. Rural women trainees should be given soft loans so they can start producing cocoyam value added products commercially.

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Climate Change Information and their Use by Small Holder Rural Farmers in Nigeria

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ABSTRACT

The study reviewed the existing literature on sources of climate change information and their use by small holder rural farmers in Nigeria. It was also found that there was a high level of awareness of climate change information in the state, with the main sources of climate change information including radio, television and extension services. Farmers also use climate change information to make decisions about what and time to plant, as well as to plant improved crop varieties, among other things. Challenges such as decreasing annual rainfall, deforestation, insect pest attacks and high temperatures, to name a few does exit. This paper recommends a more intensive climate change awareness campaign, as well as an increased budget allocation to the agricultural sector for greater mitigation and adaptation capacity for farmers.

INTRODUCTION

The news on the level of awareness, access and capacity building of vulnerable populations for climate change adaptation and/or mitigation around the world, especially in developing countries like Nigeria, is of concern to the ecologists. Over the years, world leaders have held international summits to find solutions to this global threat. According to Stevens *et al*. (2017), the most recent agreement reached by the United Nations Conference of the Parties at the World Climate Change Conference (COP21) in December 2015 was hailed by many as a watershed moment. According to them, the agreement is still strewn with pitfalls. As a result, some world leaders are questioning their full commitment to the principles of the agreement. As our interest is in the availability, awareness, access and, of course, use of climate change information, we will avoid as much technical detail as possible in this work and stick to the basic knowledge of climate change. Banmeke *et al.* (2017) pointed out that the Intergovernmental Panel on Climate Change (IPCC, 2001) defines climate change as statistically significant variation caused by human and non-human activities that lasts for decades or longer. Deforestation, oil spills and gas flaring are examples of human causes, while volcanic eruptions and ocean currents are examples of non-human causes. This definition shows that it is caused both by human activities and by uncontrollable natural circumstances. The West African sub-region would also be more vulnerable. Individually, farmers, fishermen, other rural dwellers and city dwellers are the most vulnerable groups. According to Abdulhamid (2015), some of these policies in the agricultural sector aimed at ensuring food security and self-sufficiency since 1970 included Agricultural Development Project (ADP), Agricultural Establishment and National Accelerated Food Production Program (NAFPP), Operation Feed the Nation. (OFN) etc. Despite all these laudable programs, Nigeria has not been able to achieve food security and self-sufficiency, perhaps due to the various forms of climate change plaguing it. Wakili (2018) reported that the Lake Chard basin has dried up to 10% of its original size. According to an AFP report on August 24, 2010, the Nigerian Meteorological Agency had predicted light rainfall, but it fell in torrents. That doesn't mean the agency wasn't confident in its prediction, but that climate change had an impact on it. According to Rabiu (2014), “information is knowledge communicated or received regarding a specific fact or circumstance, knowledge gained through study, communication and research”. The Nigerian government is working hard to diversify the country's economy, with agriculture as the main focus. The Federal Ministry for the Environment has created a Climate Department. Change with the mandate to drive the federal government's vision to mitigate and adapt to the impacts of climate change. Their mandate includes, among other things, providing leadership in promoting the appropriate adaptation culture, as well as supporting research, education, and awareness. Adapting to the threats of climate change by transitioning to modern climate-smart farming practices is becoming more difficult due to a lack of knowledge (Ibrahim, 2017). Beyioku (2016) reported that one of the solutions proffered by a 2 Day South-South Regional Workshop on Climate Change Capacity Building was raising awareness on issues of climate change that is presently at low level especially amongst vulnerable groups like women, children, even at the grassroots, especially rural dwellers. This indicates that awareness of climate change problems in Nigeria is low, implying that our government has not done enough to address the problem.

Awareness of the term climate change

Akpan *et al* (2012) reported that Nigerians’ understanding of climate change-related issues including the negative effect of the fast changing climate on lives is not encouraging. However, in their study, Abdulkareem *et al*. (2012) recorded that level of awareness of teachers on climate change was high with a high rate of 84% but on the contrary, the awareness rate of the students was very low with only 31% representing their awareness of the phenomenon. It is worrisome that the teachers have such a high rate of awareness while their students recorded a very low awareness level. This is an indication that it is not yet included in our schools curriculum. These children if they are aware of this phenomenon can help in spreading the information. Idoma and Mamman (2016) in their study revealed that 92% of their respondents were very aware of the term climate change and variability. They reported that high rate of their awareness is an indication that climate variability is very evident coupled with the fact that 49.2% of the farmers had over forty years of farming experience.

Climate change information

In the face of the threats posed by climate change to the world especially Nigeria, there is need for sufficient and well-timed information to be given out to the public. This information will help the people especially the susceptible to build capacity for adaptation and or mitigation of the effects of climate change. Idoma and Mamman (2016) in their study discovered that early warning signals, Rainfall Prediction, Drought Prediction, Food aid, Temperature change, Adaptation Technology, Human Health Services and Veterinary services had mean scores above two, placing them on top as needed climate change information. Similarly, Idoma and Mamman (2016) revealed the need for climate information and knowledge sharing between researchers, policy makers and community institutions in order to boost practical adaptation at the grassroots level.

Causes of climate change

Climate change or global warming is assumed to be triggered by both human and natural factors. Agreeing to Intergovernmental Panel on Climate Change (IPCC) in Onu and Ikehi (2017), the causes of climate change can be connected principally to factors such as: Industrial revolution, for instance the activities of automobiles and other industries have led to emission of several gases like carbon dioxide (CO_2) into the atmosphere which over time affects the structure of greenhouse gases leading to altered climate; Burning of fossil fuels by oil producing companies and refineries which emit greenhouse gases into the atmosphere; Land use change such as deforestation and desertification which leads to climate change, and agricultural activities such as bush burning, fertilizer application, fermentation among others, all of which are anthropological influencers of climate change (Odjugo, 2011).

Effects of climate change

Reduced rains have been observed in some parts of Nigeria especially Kaduna State, with the farmers lamenting poorer rice, maize, and vegetable output,(Ibrahim, 2017). He opined that, the long-term forecast is for still dryer conditions across the north, with the potential decline in yields for rain-fed agriculture as high as 50 percent. Low yield is one of the effects of climate change on farmers. This is as a result of irregular/random rainfall, severe heat, desert encroachment, flooding, shrinking of rivers and lakes, soil degradation, landslides, erosions among others. Dadzie *et al.* (2012) in their findings agreed with this when they reported that the production experience of the food crop farmers interviewed stated that flooding, pests and diseases outbreaks, drought and irregular rainfall are the common incidence of events they have been encountering with seasonal shifts due to climate variability and change. Sagoe (2006) also agreed with this in her report on study of climate change and root crop production in Ghana, Factors such as unreliable, irregular and unpredictable rainfall are some of the effects of climate change. Idoma and Mamman (2016) revealed major adverse effects of climate change in the area they studied as flooding of farm land, crop failure and poor harvest, poor performance and high mortality rate of livestock, wilting and decay of farm produce, poor fish harvest and unusual pests/diseases of crop and animal.

Sources of climate change information

Anunobi, and Udem, (2014) defined information as realistic data, ideas, and other knowledge stemming from any society that are acknowledged as being of value, sometimes assembled on a regular basis, organized in some fashion, communicated to others, and used in some meaningful way. This definition reveals that information is meaningless if it is not collected, processed, disseminated and used. Source and dissemination of information on climate change is very essential. Every information has a target audience and there is a right source to get that information to that very audience. It is only then that the information can be said to have been rightly and properly disseminated. Various sources of information dissemination abound, viz; the Mass Media – Print and Non-print media. Newspapers, Magazines and Radio, Television. This days the advent of Information and Communication Technology (ICT) (internet and the World d Wide Web) has provided another powerful means of information dissemination. It uses various platforms such as blogs, social media network – facebook, WhatsApp, imo, Linkden etc. as well as the Libraries, extension workers (for some technical areas), posters and handbills, community channels (town criers), and so on. Annor-Frempong and Nana Acquah (2012) in their study reported that a majority (85.3%) of their respondents used the media

(Television and Radio) for information on climate change, and it is regarded as the most effective sources. Akpan et al. (2012) conducted a study on the Influence of the Nigerian Mass Media on Public Understanding of Climate Change and discovered that Interpersonal communication, internet and television still had an edge over newspapers as sources of climate change information for the respondents. That Interpersonal communication ranked the highest among the sources of information on climate change for the respondents. It was only 19 (4.75%) respondents out of 400 who indicated having ever read a story in a newspaper on climate change. The respondents who had read newspapers did not remember reading up climate change stories. Idoma and Mamman (2016) in their study identified four major channels of climate information communication in their order of acceptance to the respondents. Community channels (extension workers, neighbours/friends) very high significant rate, Mass Media (Radio & Television) came second while Print Media (Newspapers, Pamphlets) ranked third and Electronic Media (internet, SMS) ranked fourth in there study.

Use of information on climate change

Information received becomes relevant only when it is utilized. Climate information is meant to adapt or mitigate the effects of climate change in the environment. Idoma and Mamman (2016) stated that decision on when to plant crop came first (very important), decision on when to harvests fish from ponds ranked second (important), planning mitigation for flooding was ranked third (moderately important) while general daily activities came fourth (of little importance) in there study.

Difficulties in accessing and using climate change information

Idoma and Mamman (2016) reported limited access to radio, television and internet as well as poor translation of climate change technologies with a very high percentage (94%) as barriers to communicating climate information to Agatu. Other obstacles are the technicality of the message (85%), lack of trust in the source of information (82%) and cultural barriers (80%). Their findings were corroborated by Schubert, (2014) and Speranza, Kiteme, Ambenje, Wiesman & Makali (2010) who reported that communicating climate information to support adaptation action in Africa is hampered by several contextual factors, namely socio-cultural, content-related and technological barriers. Meanwhile, most of the challenges faced by farmers, as emerged from discussions and interviews, include reduction in annual rainfall, excessive heat (high temperature), depression of groundwater, gaps between forecast and actual rainfall, soil erosion, reforestation activities, land tenure and the incidence of pests attacking our agricultural products are some of the burning issues requiring climate change information in the study area. Furthermore, besides climate change, other agricultural challenges are lack of budget allocation to support the team farming population, lack of credit facilities and weak market are the major challenges.

CONCLUSION

For the past few years, world leaders have been pondering what or how to deal with the greatest threat of the moment, erratic climate change otherwise known as climate change. These changes negatively affect the overall survival of the human race and other living organisms on the surface of the earth, as the life of all living organisms depends on water, humidity, air and soil. to survive. Air pollution caused by the emission of gases from factories, vehicles, the domestic use of firewood, etc. drastically affects the ozone layer and the earth's crust, leading to reduced precipitation, humidity and an increase in the concentration of carbon dioxide on the earth, which leads to poor agricultural produce. However, the mechanisms put in place by the government at all levels, international organizations and NGOs in the state to sensitize and encourage farmers to use the information provided have yielded good results as the levels of awareness, access and use of climate change information by farmers are high. , therefore, the state has no reason not to be at the forefront of economic diversification of this agriculture-oriented government, thus improving the socio-economic activities of its people who are really farmers.

RECOMMENDATIONS

Based on this study, the following recommendations were made:

1. Due to the threat posed by climate change to humanity in the area of food scarcity, there is an urgent need to provide the public with adequate and timely information on climate change, as this will enable people to build their capacities adaptation or mitigating the effects of this phenomenon

2. Governments at all levels should increase their budgetary allocation to agriculture and provide accessible credit facilities to farmers to enable them to insure their farms to minimize the burden of losses resulting from the effects of climate change.

3. The government and non-governmental organizations should do more to train more personnel and send them to every nook and cranny of the state to create greater awareness about current events regarding climate change; this will help people to be more proactive in managing the results of this phenomenon.

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The Role of Gender Mainstreaming in Agricultural Productivity in Wukari Local Government Area of Taraba State. Nigeria.

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ABSTRACT

This paper investigated the role of gender mainstreaming in agricultural productivity in Wukari Local Government area of Taraba State. It examined gender differentials in terms of roles performed in agricultural production, marketing, access to productive resources. On gender differentials in crop and animal production, men were more involved (45%) than female (15%). Similarly, level of involvement in crop productivity by gender (hectares) and year for the past three years (2019-2021), men were more involved while female mostly engage in processing activities. The study employed in-depth interview, focus group discussions and structured questionnaires for data collection. Findings of the study revealed that women are generally underrepresented in most profitable nodes of agricultural activities. The commercialization of agriculture has led women to lose control over the commodities they traditionally used to control, as these commodities have fallen into the hands of men. Therefore women in this category are either disempowered or at least not empowered by agricultural interventions programmes. Nevertheless, for women of FHHs, gender mainstreaming in agricultural has contributed to improving gender equality, employment, and women's empowerment by boosting their economic, social, and personal empowerment levels, though they still lag behind the men in many aspects of agricultural enterprise. It is concluded that women are less involved in almost all aspects of agricultural productivity because of lack of access to productive inputs. It is therefore recommended that

Improving access to productive resources and market services, provisions of services, loans, subsidies, and capacity development can enhance productivity of particularly women.

Key Words: Role, Gender Mainstreaming, Agricultural Productivity, Wukari Local Government, Taraba State

INTRODUCTION

Gender mainstreaming was established in 1995 as an intergovernmental mandate in the Beijing Declaration and Platform for Action (Ababe *et al.*, 2006). Gender mainstreaming emerged as a response and a strategic solution to the shortcoming of women's- focused policies which failed to significantly address the gender disadvantage. Gender mainstreaming as a strategy "represents a shift of policy focus from women-focused policies to a more strategic attention of mainstreaming gender across all organizations as a means of achieving gender equality and women's empowerment (Elliston, 2006). According to Bera (2015), gender mainstreaming is a means by which the gender equality will be realised, it is more than increasing women's participation as it places gender equality at the centre of planning, policy decisions, program budget, and institutional structures and processes and recognizes the importance of incorporating women's and men's perceptions, experiences, knowledge, and interests into these processes. This section presents historical overviews of gender mainstreaming, strategies and conceptual framework of gender mainstreaming as well as the limitation and critiques of gender mainstreaming. Mainstreaming a gender perspective is the process of assessing the implications for women and men of any planned action, including legislation, policies or programs, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring, and evaluation of policies and programs in all agricultural, political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality. A common example of gender mainstreaming is providing training to strengthen women's skills and capacity. But gender mainstreaming goes beyond increasing women's participation. It means bringing the experience, knowledge, and interests of women and men to bear on the development agenda. The goal of mainstreaming gender equality is the transformation of unequal social and institutional structures into equal and just structures for both men and women in the targeted organizations. The mainstreaming activities specifically target women's priorities and needs, though, for example, legislation, policy development, research and projects/programs on the ground. Women-specific projects continue to play an important role in promoting gender equality. And yet, they are still needed because gender equality has not yet been attained and gender mainstreaming processes are not well developed (Chawa *et a*l., 2001).Nevertheless, gender mainstreaming is still seen as the most "modern" approach to gender equality (Daly, 2005). The study answered the following research questions:

1. To what extent are women benefiting from gender mainstreaming?
2. How women's involvement in agricultural production does contributes to their empowerment?
3. What are the constraints to gender equity and women's participation in agricultural production?

METHODOLOGY

Study Area

Wukari is a Local Government Area in Taraba State, Nigeria. Its headquarters is in the town of Wukari on the A4 highway. The Donga River flows through the area and the Benue River forms a boundary with Nasarawa State to the northwest. It has an area of 4,308 km^2 and a population of 241,546 at the 2006 census. The Wukari Federation is a traditional state in Nigeria, a successor to the Kwararafa state of the Jukun people. The ruler takes the title "Aku Uka" The Jukun were established in Wukari as early as the 17th century. The town was one of the southern centers on a trading route that connected via Bauchi to the northern states of Katsina, Kano and Bornu (NPC, 2006)

Sampling Procedure and Sample Size

Simple random sampling procedure was employed to select 30 male farmers and 30 female farmers bringing a total of 60 respondents used as the sample size for the study

Data Collection

The data collection methods used in the study are structured interviews, focus group discussions, and structured questionnaires.

Data analysis

This study employs qualitative content analysis and descriptive statistics for data analysis from the information collected through in-depth interview, focus group discussion and questionnaire schedule.

RESULTS AND DISCUSSION

Socio-economic profile of the respondents

Table1 indicates the demographic characteristics of the participants who were involved in structured interviews and focus group discussions, out of which 30 were engaged in in-depth interviews. The participants of the research in this study are classified into three groups: male-head of household 33.3%, female head of household 41.7%, and women in MHHs 25%. As indicated in total, women (66.7%) outnumbered men (33.3%). This was deliberate because of the need to include women from MHHs as they are also one of the actors of agricultural productivity. The majority of the

Research participants (68.3%) were between 35 and 60 and the remaining 21.7% and 10% were 18-35 and above 60, respectively. Therefore most of the data were obtained from economically active member of household with longer years of experience of working in the agricultural sector.

Table 1: Demographic characteristics of the respondents

Characteristics	Variables	N	Percentage
Sex	Male	40	66.7
	Female	20	33.3
	Total	60	100
Age	18-35	13	21.7
	35-60	41	68.3
	above 60	6	10.0
Education level (men)	Illiterate	1	5.0
	Primary Edu	12	60.0
	Secondary Edu	7	35.0
	Tertiary Edu	0	0.0
Education level (women)	Illiterate	8	20.0
	Primary Edu	30	75.0
	Secondary Edu	2	5.0
	Tertiary Edu	0	0

Title in household	Male heads	25	41.7.
	Female heads	20	33.3
	Women in male head	25	41.7
	Total	60	100

Source: *Field data 2022*

Table 2 analyses gender roles in agricultural productivity. It is important to note that one participant may be involved in more than one activity in the production process. Therefore the figures indicated are not exclusive of one another. For instance, a producer might perform both production and processing activities or can be into animal production activities. Table 3 shows that the level of involvements of research participants along crop and animal production were highly gendered. The participation of men along the functions of agricultural production nodes are fairly distributed from production to marketing. Women's involvement were largely concentrated in the processing activities as well as to less extent in retailing activities of crops and animals (Bitew *et al.,* 2015).As indicated, women were absent in input provision activities, and other marketing activities such as collecting and wholesaling. Therefore women are primarily incorporated and benefited in crop and animal production. In both crop and animal production, most coordinating activities were run by men. Women are underrepresented in the management positions of agricultural activities. For instance, out of the total men interviewed, 30 percent reported that they are members of agricultural managing committee, while only 2 (5%) out of 40 interviewed women reported that they are member of agricultural management committees.

Table 2: Participants' involvement in Agricultural production and value chains activities by gender

Value chains	Male		Female	
	number	**percentage**	**number**	**percentage**
Input suppliers	4	20	0	0
Crop producers	30	75	5	10
Labour supply	1	5	9	23
Collectors	4	20	0	0
processors	2	10	20	50
Wholesalers	5	25	0	0
Retailers	4	20	10	25
Animal production	6	30	2	5

Source: *Field data, 2022*

Table 3 describes gender differences in crop and animal production. The study assessed household productivity of the main crops and main animals. It was found out that male are more involved in crop and animal production. This is because MHHs have scored higher productivity of quintals per hectare than females. Differences in household productivity between male-headed and FHHs can be related with the differences in access to productive inputs and support services between the households. Limited access to productive inputs such as seeds, and chemical fertilizer as well as production support services will affect the productivity of the farm activities of FHHs. Added to this, the problem of limited access to market and market information, labour shortage and other institutional constraints are also the main cause for the low productivity of FHHs. Evidence from other African countries reveals that differences in productivity per unit area of land between men and women farmers attributes to the difference in the amount of labour and other resources used per plot. Women-controlled plots usually receive less amount of labour and other inputs and consequently produce less amount of yields than men-controlled plot (Carranza, Goldstein and Oseni, 2014).

Table 3. Gender differentials in Crop and Animal production

Agricultural Production	Total participants	Men participants	Women participants	Men owners	Women owners	Men employee	Women employees	Women family La
Crop Production	35	25	10	16	12	2	5	8
Animal Production	25	20	5	14	8	0	3	9
Total	60	45	15	29	20	3	8	17

Source: *Field data 2022*

Table 4 describes gender differences in crop productivity. The study assessed household productivity of the main crops in the last three production years (2019 to 2021). It was found out that for all the main crops, MHHs have scored higher productivity of quintals per hectare for the years indicated in Table 3.Differences in household productivity between male-headed and FHHs can be related with the differences in access to productive inputs and support services between the households. Limited access to productive inputs such as seeds, and chemical fertilizer as well as production support services will affect the productivity of the farm activities of FHHs. Added to this, the problem of limited access to market and market information, labour shortage and other institutional constraints are also the main cause for the low productivity of Female Household Heads. Carranza, Goldstein and Oseni (2014) posits that, evidence from other African countries reveals that differences in productivity per unit area of land between men and women farmers attributes to the difference in the amount of labour and other resources used per plot. Women-controlled plots usually receive less amount of labour and other inputs and consequently produce less amount of yields than men-controlled plot (Bera, 2015).

Table 4. Assessment of the level of crop production of main crops by gender (hectares) and year

Year	Roots and Tubers		Cereals		Pulses		Vegetables	
	male	**female**	**male**	**female**	**male**	**female**	**male**	**female**
2019	40.0	30.0	36.3	28.0	22.5	16.6	54.5	41.4
2020	38.0	27.5	37.0	25.0	24.0	15.0	62.5	45.0
2021	42.0	30.0	35.7	25.5	26.0	18.0	60.9	45.0

Source: *Field data, 2022*

CONCLUSION/ RECOMMENDATIONS

It is concluded that gender mainstreaming in access to and use of resources, productive inputs and agricultural support services should be encouraged due to the socio-cultural and institutional barriers that constrain women's equal access to those resources. In the study area the agricultural development program has largely neglected the gender perspectives mainly due to the rhetoric of male-dominated household headship that obscured women and their contributions in agricultural productivity. The following are some of the recommendations put forward.

- The incentive for agricultural production should be made available to everyone irrespective of gender.

- Improving access to productive resources, market services, loans, subsidies, and capacity development that push the disadvantaged group of farmers, particularly women should be encouraged, reinforced and sustained.
- The delivery of the general agricultural extension services should be designed to target both male and female household heads.

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Response System And Adaptation Strategies To Climate Change By Yam Farmers In The Niger-Delta Area Of Nigeria

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ABSTRACT

Agriculture is the sector mostly affected by climate change. This is not unconnected with the fact that the key elements within which agriculture thrives is the climate. The devastating impact of climate change on livelihood and the environment is a cause of concern in the Niger-Delta area of Nigeria and this have had tremendous effect on yam production in the area. The study was to identify response system and adaptation strategies by yam farmers in the study area. A multistage sampling procedure was used and structured questionnaire administered for primary data to yam farmers, with 216 viable questionnaires retrieved for analysis. The Multinomial Logit (MNL) model showed how socio-economic, institutional, households and farm characteristics influenced yam farmers' choice of adaptation measures in the study area. The result revealed that the major adaptation strategies employed by yam farmers were mixed cropping (30.5%), planting different varieties (24.0%) and soil conservation techniques (20.3%). Also, that socio-economic characteristics like gender, marital status, access to extension, access to credit, age, farm size, farming experience, farm income and household size were the major factors influencing the choice of adaptation measures employed by the yam farmers in the study area. It can therefore be submitted that mixed cropping/farming and soil conservation techniques were key adaptation strategies employed by the yam farmers and socioeconomic characteristic (farm income, access to extension, farming experience) were pivotal to adaptation choices used by the farmers.

1.0 INTRODUCTION

Climate change is one of the most serious environmental threats facing mankind worldwide. Ifeanyi-obi, Etuk and Jike-wai. (2012) posited that there are four major causes of climate change: astronomical causes, volcanic eruptions, variations in solar output and changes in earth's environment as a result of human activity. The devastating impact of climate change on livelihood and the environment is a cause of concern in the Niger Delta area of Nigeria. It is important to highlight that Delta region is one of the most volatile coastal regions with some worsening levels of ecological hazards in Sub-Saharan Africa. According to Ugo-Ikem (2015) the Niger-Delta region of Nigeria is characterized by lowlands with most of the Delta being less than 6m above sea level, making the region very much exposed to rise in sea level. The abundant rivers, creeks and streams expose the region to adverse environmental negative impacts with significant flooding resulting from inland surface waters and the boundary coastal shelf. Food production has been adversely hit by the recurring climate change induced flooding in most part of the area.

Study by Woodley (2011) revealed that climate change has untold impact on health, human settlement, energy, agriculture and food security on the coastal area. Similarly, Rural Linkage Network (2013) also noted that Delta State has been experiencing climate change related impact such as: rising temperature, heat waves, more intense rain/wind storms, more extreme rains, including: erosion and landslides, sea level rise, sea surges and coastal inundation.

Yam is an important food and cash crop in West Africa and provides livelihood to over 60 million people in the region (Djana *et al.*, 2014). The issue of Climate change have also had debilitating effect on yam production in the Niger Delta. Ohagwa (2017) quoted that "Climate change is here with us. We have to tackle it. It has a lot of opportunities for us in Niger Delta". Therefore, the need to look at the response system and adaptability measures taken to cushion the effect of climate change in this area becomes imperative.

2.0 MATERIALS AND METHOD

The study area is the Niger-Delta area of Nigeria. It comprises of nine states namely, Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo, Rivers, Ondo, Imo and Abia States. Both primary and secondary data were used for this study. For the primary data, structured questionnaire was administered to yam farmers gotten through a multistage sampling procedure in the study area. In all a total of two hundred and forty (240) respondents for the study. However, a total of 216 viable questionnaires were finally retrieved for analysis.

2.1 Multinomial Logit Model for Adaptation Strategy

Multinomial Logit (MNL) was employed to examine the factors that influence the choice of adaptation measures used by yam famers in the study area. The MNL is a generalization of the logistic regression model to the case where there are more than two outcomes, and where the outcomes are not ordered.

Let Y_1 be a random variable representing the adaptation measure options chosen by any farming household taking on the values {1,2,...J} for J, a positive integer, and

Let X represents a set of conditioning variables which represent household attributes/socioeconomic characteristics.

The question is how ceteris paribus changes in the elements of X affect the response probabilities P(Y =j/X),j = 1.2,...J

Since the probabilities must sum to unity, P(Y = j/X) is determined once we know the probabilities for j = 2,…….J

Let X be a 1 x K vector with first element unity.

The MNL model has response probabilities:

$P\,(Y\,j/X) = \exp\,(X\beta j\,)/\,[1 + \sum_{h=1}^{j} exp(X\beta_h), j = 1,..\,.J]$ ……………………………….. (1)

Where β_j is K x 1,j = 1.. J.
Differentiating equation (1) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:
$\frac{\partial P_j}{\partial X_K} = P_j\,(\beta_{jk} - \sum_{j=1}^{j-i} P_j\beta_{jk})$... (2)
The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Deressa, Hassan, Alemu & Yesuf, 2008 and; Fatuase & Ajibefun, 2014).
The explicit function of the MNL model is given below:
$Y^* = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta 4X4 + \beta_5X_5 \ldots + \beta 11X11 + \beta_{12}X_{12} + \beta_{13}X_{13} + e_1$ .... (3)
Where:
Y* = dependent variables (Adaptation measure options) which are:
1 = Different Planting Dates (DPD), 2 = Practicing Crop Diversification (PCD)
3 = Mixed Cropping (MC), 4 = Soil Conservation Techniques (SCT)
5 = Use of Agro-chemicals (UAC) ,6 = Move to Different Sites (MDS),
MDS was chosen as the base category.
While; the Xis are the explanatory variables, which are:
X_1 = Age of respondent (Years).X_2 = Gender of household head (dummy: 1 = Male and 2 Otherwise) X_3 = Marital status (1 =married and 2 otherwise) X_4= Household size (Number) X_5 = Educational level of household head (years spent in school). X_6 = farm size (ha) X_7 = farming experience (years), X_8 = Access to extension services (yes = 1, 0 otherwise) X_9 Access to credit (yes = 1, 0 otherwise), X_{10} = Farm income (naira),ε= the error term.

3.0 RESULTS AND DISCUSSION

3.1Major Adaptation Measures Commonly Employ by Yam Farmers in the Study Area

The study identified various adaptation strategies to climate change, relevant and engaged by yam farmers in the area. As shown in Table1, about 30.5% of the yam farmers identified “Mixed cropping/farming” as their main means of adaptation strategy used in the study area. The greater use of this adaptation measure is not unconnected to the fact that people tend to resort to a closely complementary alternative when an earlier enterprise they know is threatened. About 24% of the yam farmers adopted “Planting different varieties” as their adaptation measure while 20.3% of them employed soil conservation technique, to guide against uncertainty in the area. Similarly, 16.2% of the respondents adopted “Different planting date” measure as a way of dealing with the challenge of climate change. In addition, 4.3%, 2.6% and 2.1% of the sampled respondents employed “Moving to different site”, “Use of agrochemicals” and “Practicing crop diversification” respectively as adaptation strategies in the study area and this aligns with the findings Bradshaw *et al.* (2004) and Deressa *et al*. (2008).

Table 1: Major Adaptation Measures Employed by Yam Farmers in the Study Area Adaptation Measures

Adaptation Measures	Frequency	Percentage

Mixed Cropping/Farming (MC/F)	64	30.5
Planting Different Varieties (PDV)	52	24.0
Soil Conservation Techniques (SCT)	44	20.3
Different Planting Dates (DPD)	35	16.2
Move to Different Site (MDS)	10	4.3
Use of Agrochemicals (UAC)	6	2.6
Practicing Crop Diversification (PCD)	5	2.1
Total Sample Size	**216**	**100.0**

Source: Computed from field survey, 2018

3.2 Factors Influencing Choice of Adaptation Strategies to Climate Change in the Study Area.

This section presents the results of MNL model that showed how socio-economic, institutional, households and farm characteristics influenced yam farmers' choice of adaptation measures in the study area.

The MNL failed to produce satisfactory results in terms of significance level of the parameters estimates when the seven identified adaptation options were first run. This was thus restructured by grouping closely related choices together in the same category. In this case, Planting different varieties and Different planting dates were grouped together as the same category, labelled "Planting Different Varieties". Similarly, Soil conservation techniques and Use of Agrochemicals were grouped together as same category and labeled "Soil conservation techniques".

The MNL adaptation model with these restructured choices was ran and it showed some significant levels of the parameters estimates. Table 2 showed the results of MNL diagnostic tests. The results revealed that all the parameters showed the goodness of fit. The likelihood ratio statistics as indicated by $\chi 2$ statistics (24.29) are fairly significant ($P < 0.0463$) suggesting the models have a strong explanatory power. The estimated coefficients were compared with the base category/outcome which is Move to Different Site (MDS) in the case of this study.

Table 2: Results of Diagnostic Tests of the MNL Regression Analysis

Parameters	Results
No of observations	102
LR Chi-Square	24.29
Prob > chi2	0.0463
Log likelihood	-145.1804
Pseudo-R^2	0.0772

Source: Computed from field survey, 2018

Therefore, Table 3 presents the marginal effects of the MNL results along with the levels of statistical significance. The results were discussed based on each adaptation options in the study area.

Planting Different Varieties (PDV): Three out of the ten variables examined in the study statistically influenced the likelihood of adopting Planting Different Varieties over the base outcome (Move to Different Site). The coefficient of gender is positive and significant at 1% level. This indicated that the male respondents have a higher chance of adopting Planting Different Varieties than female respondents by 1.02 units. The coefficients of access to extension and credit are positive and significant at 5% level, showing that more access to extension and credit increases the chance of adopting Planting Different Varieties by 0.70 and

0.71 units respectively compared to Move to Different Site (Table 3).This results on gender from the States, is in line with the argument that male-headed households are often considered to likely get more information about new technologies and take more risk than female-headed households (Deressa, 2008 and Deressa et al., 2010).

Mixed Cropping/Farming (MC/F): Three out of the ten variables examined in the study area, statistically affected the likelihood of adopting Mixed Cropping/Farming over the base category. Age and farm size are significant at 1% while farm income is significant at 5%. The coefficient of age is negative and showed that an increase in the age of the respondents reduces the probability of adopting Mixed Cropping/Farming over the base category/outcome by 0.08 units while the coefficients of farm size and farm income are positive, indicating that an increase in the farm size and farm income of the respondents increases the probability of adopting Mixed Cropping/Farming by 0.25 and 3.12e-06 units respectively instead of base category.

Soil Conservation Techniques (SCT):Four out of the ten variables examined, statistically influenced the likelihood of adopting Soil Conservation Techniques over Move to Different Site (base outcome). The coefficient of age is negative and significant at 1% level. This indicated that older farmers have a lower chance of adopting Soil Conservation Techniques than younger respondents by 0.07 units. The coefficients of marital status, farming experience and farm income are positive and significant at 5% level, revealing that married respondents and respondents that have higher farming experience and farm income have better chances of adopting Soil Conservation Techniques by 0.61, 0.03 and 2.88e-06 units respectively compared to base outcome.

Table 3: Result of the Marginal Effect of MNL on Yam-based Climate Change Adaptation Strategies in the Study.

Variables	Planting Different Varieties (PDV)	Different Planting Dates (DPD)	Mixed Cropping/Farming (MC/F)	Soil Conservation Technique (SCT)
Age	-0.043 (0.801)	-0.058 (0.039)**	-0.076 (0.004) ***	-0.071 (0.003)***
Gender	1.022 (0.002)***	1.134 (0.003)***	0.452 (0.765)	0.127 (0.102)
Marital Status	-0.156 (0.451)	-0.122 (0.392)	-0.253 (0.821)	0.612 (0.030)**
Household Size	0.099 (0.878)	0.134 (0.672)	0.045 (0.123)	-0.018 (0.189)
Education Level	-0.004 (0.478)	0.059 (0.610)	-0.049 (0.723)	-0.048 (0.893)
Farm Size	-0.111 (0.476)	-0.296 (0.034)**	0.248 (0.005)***	-0.120 (0.653)
Farming Experience	0.011 (0.856)	0.032 (0.034)**	0.007 (0.709)	0.027 (0.025)**
Access to Extension	0.700 (0.031)**	0.624 (0.050)**	-0.170 (0.679)	-0.133 (0.598)

Access to Credit	0.710 (0.039)**	-0.730 (0.030)**	0.048 (0.345)	0.283 (0.601)
Farm Income	-1.25e-07 (0.431)	-3.09e-07 (0.301)	3.12e-06 (0.019)**	2.88e-06 (0.038)**
Constant	-0.384 (0.220)	-0.996 (0.089)	0.845 (0.102)	0.426 (0.815)

Base outcome = Move to Different Site; Number of observations = 102
Note: ***' **' * significant at 1%, 5% and 10% respectively.

4.0 CONCLUSION

Based on the findings of this study, it can be concluded that the main adaptation strategies employed by the yam farmers are; planting different varieties, practicing crop diversification, mixed cropping/ farming, soil conservation techniques and move to different site. Also, that socio-economic, households and farm characteristics like gender, marital status, access to extension, access to credit, age, farm size, farming experience farm income and household size were the major factors influencing the choice of adaptation measures employed by yam farmers in the study area.

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Socio-Economic Determinants of Adoption of Tms Cassava Production Technologies in Ivo Local Government, Area of Ebonyi State,Nigeria.

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ABSTRACT

This study was designed on examining the socio-economic determinants of adoption of TMS cassava production technologies in Ivo Local Government Area of Ebonyi State, Nigeria. Specifically, the objectives were to identify the TMS cassava production technologies used by smallholder cassava farmers in the study area; examine the socio-economic factors leading to adoption of TMS cassava production technologies in the study area ; identify the cassava production techniques used by smallholder cassava farmers in the study area; identify the TMS cassava production constraints affecting the smallholder cassava farmers in Ebonyi State. Multistage sampling technique was employed to select the local government area, communities, villages and farmers. A total of 84 respondents were identified and selected using this sampling technique. Data from these respondents were analysed using descriptive statistics (frequency, tables) and inferential tools (Binary Probit model).It was however, deduced that high cost of planting materials, lack of fund(credit facilities),lack of labour for farming activities were major constraints affecting farmers production of TMS cassava in the study area.The result showed that the marital status of the farmer, age of the farmer, household size, farming experience and farm size were what significantly influenced the adoption of TMS cassava production technologies by farmers in the study area. It was however recommended that extension institutions in the study area should encourage farmers to adopt TMS cassava production technologies and also financial institutions, both governmental and private institutions should make loans available to farmers at affordable interest rates.

Keywords: Socio-economic, determinants, adoption, cassava production, technology

INTRODUCTION

The adoption of improved agricultural technologies is needed to improve agricultural productivity, which serves as the panacea to food insecurity and economic recovery for a country(Ojeleye et al.,2017).In Nigeria, despite projects, programmes and policies targeted at reducing the problem of hunger in the land, the country is still ranked 34^{th} on the Global Hunger Index(GHI) of 50 countries, with a Global Hunger Index of 25.5 indicating a serious hunger situation(International Food Policy Research Institute,IFPRI,2017).Thus, research and adoption of technological improvement are crucial to increasing agricultural productivity and food security(International Fund for Agricultural Development,IFAD,2011). Nigeria accounts for cassava production of up to 20% of the world, about 34% of Africa's and about 46% of West Africa's(FAO,2017). The national average yield of cassava is estimated to be at about 13.63MT/Ha which is grossly different against the potential yield of up to 40MT/Ha(FAO,2017). Despite the introduction of several government initiatives directed at improving cassava production in the country. Some of these initiatives include and not limited to the president Olusegun Obasanjo's Presidential Initiative(PI) for cassava production of 2002(Ojeleje et al.,2017).This presidential initiative involves the International Institute of Tropical Agriculture(IITA), National Root Crop Research Institute(NRCRI),National Agricultural Research Services(NARs),Agricultural Development Programmes(ADPs) and some other partners to develop and disseminate high yielding and disease-resistant cassava varieties(Ojeleye et al.,2017).Through these initiatives, a number of varieties were released and promoted. Unfortunately, most of the farmers in the rural areas still use the local cassava varieties as planting materials, which in turn gives very poor yield hence, contributing to food insecurity, given the important role cassava plays in the typical Nigerian diet (Ojeleye et al.,2017).The rate of consumption of cassava in the country led to an increase in the demand for this crop both for food and for industrial uses, which exceeded its supply(Agwu and Anyaeche,2007).To reverse this trend, the International Institute of Tropical Agriculture(IITA) and National Root Crop Research Institute(NRCRI) in Nigeria led the development of improved cassava cultivars through their breeding programmes to obtain higher quality cassava roots at relatively shorter time and pest/disease resistant cassava cultivars capable of adapting to a wide range of ecological conditions and farming systems(Agwu and Anyaeche,2007).The general objective of the study seeks to examine the socio-economic determinants of adoption of TMS cassava production technologies in Ivo Local Government Area of Ebonyi State ,Nigeria. The specific objectives are to identify the TMS cassava production technologies used by smallholder cassava farmers in the study area; examine the socio-economic factors leading to adoption of TMS cassava production technologies in the study area ; identify the cassava production techniques used by smallholder cassava farmers in the study area; identify the TMS cassava production constraints affecting the smallholder cassava farmers in Ebonyi State.

MATERIALS AND METHODS

The study was conducted in Ebonyi State, Nigeria.The State has a total number of thirteen Local Government Areas(LGAs) that are demarcated into three agricultural zones namely:Ebonyi North, Ebonyi Central and Ebonyi South Zones. The people of Ebonyi State are predominantly farmers. They grow crops like cassava, rice, yam, cocoyam, maize, vegetables, fruits and as well as keeping of some small ruminants and rearing of cattle(Echiegu,2002).There exit huge salts deposits at Okposi and Uburu salt lakes, the biggest salt deposit in Nigeria.The population for the study was cassava farmers in Ebonyi State Nigeria. Data were collected with the aid of a structured questionnaire that was administered to the respondents. A four stage random sampling technique was used in selecting community, villages and respondents. Firstly, Ivo local government area was purposively selected. This was due to the fact that there was low adoption of TMS cassava production technologies in the local government area. Secondly, three(3) towns were randomly selected out of five(5) towns namely Amonye, Amagu, Akaeze, Okue and Amokwe.Thirdly,four(4) villages were randomly selected from each of the towns. This gave a total of twelve(12) villages. Fourthly, seven(7) farmers were randomly selected from each of the villages.This gave a total of eighty four(84) farmers

The general form of the adoption of binary probit model can be specified explicitly as:

$Y=\beta_0+\beta_1X_1+\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots B_8X_8+\varepsilon_1$

Where

Y= Adoption of TMS cassava production technologies(y=1 if farmer adopts the TMS cassava production technologies,y=0 if otherwise)
X_1=Gender(dummy variable,1=male,0=female)
X_2 =Marital Status (1 if a farmer is married and 0 if otherwise)
X_3 =Age of the farmer(years)
X_4 =Educational level of farmers (number of years of formal education)
X_5 = Household size (number of persons)
X_6 =Occupational status (1=full-time farmer,0=part-time farmer)
X_7 =Farming experience (years of cultivating cassava as disclosed by the farmer)
X_8 =Farm size(hectares)
E_1 =Error term

RESULTS AND DISCUSSION.

Table 1.0: Frequency distribution of respondents according to the cassava production technologies used

Production Technologies	Frequency	Percentage(%)
TMS 30555	50	59.52
TMS 30572	51	60.71
TMS 92/0326	48	57.14
TMS 4(2)1425	47	55.95
TMS 98/0581	48	57.14
Others	43	51.19

Source: Field survey,2022

Multiple responses

Table 1 reveals that 60.71% of the respondents confirmed that they made use of TMS 30572.This implies that majority of the respondents were familiar with TMS 30572 and hence it was highly adopted by the farmers.This however,supports the study of Udensi et al.,(2011) that despite the introduction of TMS cassava production technologies by various research institutes through integrated farming project, there still remained a very low adoption level by farmers.

Table 2.0:Frequency distribution of respondents according to the cassava production techniques used.

Production Techniques	Frequency	Percentage(%)
Land preparation	68	80.95
Planting techniques	51	60.71
Proper spacing	43	51.19
Proper and timely weeding	51	59.52
Use of pesticides/insecticides	50	57.14
Use of fertilizer/manure	48	55.95
Use of TMS planting materials	47	55.95
Use of irrigation	12	14.
Harvesting techniques	60	71.43

Source:Field survey,2022

Multiple responses

Table 2.0 reveals that 80.95% confirmed that they prepared their land before cultivation. This implies that majority of the cassava farmers prepared their farm lands before they planted. This finding supports the findings of Okuthe, (2014) that land preparation is essential for improved output.

Table 3.0: Probit regression estimates on the Socio-economic factors leading to adoption of TMS cassava production technologies.

Variable	Coefficient	Std error	t-value
Constant	--10.4882	4.3012	-2.44**
Gender	-1.0741	0.8151	-1.32
Marital Status	0.0758	0.0561	1.35**
Age	1.4511	0.7618	1.90***
Education Level	-2.1728	0.8027	-2.43
Household Size	-0.1406	0.1905	-0.74***
Occupation	3.1811	1.2551	2.53
Farming Experience	0.1408	0.0588	2.39***
Farm Size	0.00003	0.0000009	3.41***
Chi square	86.26***		
Pseudo R^2	0.7878		

*, ** and *** is significant at 10%, 5% and 1% level of probability respectively.

Source:Field Survey,2022

The results show that the chi square value of 86.26 was highly siginificant at 1% level of probability indicating that the model is a good fit. The R^2 value of 0.7878 also indicates 78.78% variability in examining the socio-economic factors leading to adoption of TMS cassava production technologies as explained by independent variables. The marital status of the farmer, age of the farmer, household size, farming experience and farm size were what significantly influenced the adoption of TMS cassava production technologies by farmers.

Here, the coefficient of marital status was positive and significant at 5% level of probability.The coefficient of age was negatively at significant at 1% probability level. This suggests that as farmer advances in age, the risk aversion increases, and the likelihood to increase the number of improved varieties adopted becomes less. This result agrees with the findings of Donkor and Owusu, (2014) that as a farmer ages, the tendency to adopt improved technologies reduces. The coefficient for household size was significant at there1% and positively related to influence the adoption of TMS cassava production technologies. This matches the findings of Donkor and Owusu,(2014) that an increase in farmer's household size increases the probability of adopting improved varieties.There was positive relationship at 1% between the experience of farmers and adoption of TMS cassava production technologies. Onyebinama(2004) said that previous experiences in farm business would enable the farmer to set realistic cost and time targets, allocate and utilize resources efficiently and identify production risk.Farm size was found to be positively significant at 1% to adoption of TMS cassava production technologies.

Table 4.0: Frequency distribution of TMS cassava production constraints

Constraints	Frequency	Percentage(%)
High cost of planting materials	58	69.05
Lack of fund (credit facilities)	41	48.81
Lack of labour for farming activities	38	45.24
Inadequate planting materials	33	39.29
Small farm size	28	33.33
Poor soil fertility	22	26.19
Prevalence of pests and diseases	19	22.62

Lack of education	18	21.43
Poor quality of planting material	14	16.67
Lack of market for cassava	11	13.10
Drought	10	11.91
Lack of Irrigation facilities	5	5.95

Source:Field survey,2022

Multiple responses.

Table 4.0 shows that majority of the respondents (69.05%) affirmed that their major constraint to TMS cassava production was the high cost of TMS planting materials. This implies that TMS cassava production in the study area was limited because of high cost of TMS planting materials as stated by majority of the respondents. This finding however agrees with Ezeano et al.,(2017) who opined that high cost of planting materials, lack of extension services, high labour cost, unavailability of improved varieties and high cost of fertilizer were the major constraints to cassava production.

CONCLUSION

Several studies have reported issues related to adoption of technologies and factors that influences adoption of technologies. This study revealed that majority of cassava farmers were females and they had attained secondary education. It was however deduced that marital status, age, household size, farming experience and farm size were significantly related to adoption of TMS cassava production technologies. Furthermore, high cost of planting materials, lack of fund(credit facilities),lack of labour for farming activities were major constraints affecting farmers production of TMS cassava.

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Economics Analysis of the Profitability in Yam Production Among Farmers in Abakaliki Local Government Area of Ebonyi State, Nigeria.

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ABSTRACT

This study was on economics analysis of the profitability in yam production among farmers in Abakaliki Local Government Area The specific objectives were to determine the factors that affects yam production, to estimate the profitability in yam production and to identify the constraints to yam production in the study area. Descriptive and inferential statistics were used as tools for analysing data. Multi-stage random sampling technique was employed to select 120 women farmers. The primary data generated were analysed using both descriptive and inferential statistics such as frequency distribution tables, percentages and Ordinary Least Square(OLS) multiple regression technique. Among the functional forms tried namely the linear, exponential, cobb-douglas and semi-log functional forms, the exponential functional form gave the best fit and therefore was chosen as the lead equation with high R^2 value of 0.712.The profitability estimation of yam production among farmers in the study area reveals that yam production was a very viable enterprise, the result obtained revealed a profit of ₦317,700.The profitability estimation shows that for every ₦1 invested in yam production resulted in a yield ₦1.72.Farmers and yam producers should be encouraged to form cooperative societies in order to have access to improved productive inputs from government at reduced rates. Extension agents should be motivated to efficiently discharge their duties by giving them incentives and paying them out of pocket expenses while performing their duties. Government should help in the development of infrastructure for efficient and effective yam production system.
Keywords: Economics, Analysis, Profitability, Yam Production,

INTRODUCTION

Agriculture, a major resource based activity in terms of capital, and labour utilization has the potential of increasing Nigerian's food self-sufficiency(Bamire and Amujoyegbe,2010).The food crop sector(maize, sorghum, millet, rice, yam, cocoyam and cassava) as the main food crops in the country contributed to about 28% to Gross Domestic Product(GDP) representing 75-76% of the share of the agriculture sectors contribution to GDP(CBN,2012).Yam (Dioscorea spp) is an annual tuber which belongs to the family of Dioscorea species can be grown in nearly all tropical countries provided that water is not a limiting factor.Yam is however, one of the principal root crops in Nigeria both in terms of land cultivation in volume and value of production. Although, yams are grown throughout Africa, but Nigeria is said to be world's largest producer of yam, accounting for over 70-75% of the world's total output(CBN,2012).It is one of the carbohydrate foods that is nationally superior to most roots and tubers in terms of digestible proteins and mineral (calcium,magnesium and potassium)(Ebewore et al.,2013). It is more resistance to drought, pest, diseases and can tolerate different climate and edaphic conditions(Ugwumba and Omojola,2012). The high cost of seed yam was the major problem of yam production in the study area.This necessitated this study which its broad objective is on the economics analysis of the profitability of yam production among farmers in Abakaliki Local Government Area.The specific objectives were to determine the factors that affects yam production,to estimate the profitability in yam production and to identify the constraints to yam production in the study area.

MATERIALS AND METHODS

The study was conducted in Abakaliki Local Government Area of Ebonyi State.Abakaliki is a local Government Area situated at the heart of Ebonyi State.The municipal council is located 64 kilometers Southeast of Enugu State and are predominantly members of the Igbo speaking tribe with a population of 79,280 according to NPC(2006) population census. Abakaliki local government Area of Ebonyi State has a temperature of 27^0C and mean annual rainfall of 1800-2000mm.Majority of the population are farmers, engaging in the production of arable crops like yam, cassava, rice melon,groundnut, maize, millet and sorghum(ESBS,2018).The people are also involved in quarrying and other economic activities like golf course and hotel businesses.Data were collected with the aid of a structured questionnaire that was administered to the respondents.Multi stage random sampling technique was used in selecting respondents from community and villages. Firstly, a community was purposively selected from Abakaliki local government area. Secondly, six villages were randomly selected from the community.Thirdly, twenty farmers were randomly selected from each of the villages and this gave a total of one hundred and twenty(120)farmers. Objective i was analysed using gross margin analysis ,objective ii was analysed using inferential statistics of Ordinary least square regression analysis while descriptive statistics such as percentage, frequency table and mean was used to analyse objective iii.

Model Specification

Multiple Regression Model

Model can be implicitly represented as

$Y=F(x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8,x_9,x_{10}+ei)$

Where;

Y= yam output(kg)

X_1=Gender(male=1,female=0)

X_2=Age(years)

X_3=Farm size(ha)

X_4=Farm Experience(years)

X_5=Extension(visits=1,No visit=0)

X_6=Labour(manday)

X_7=Seed minisett(Available=1,Not available=0)

X_8=Agro-Chemical(Available=1,Not available=0)

X_9=Household Size(Number)

X_{10}=Educational Level(years)

RESULTS AND DISCUSSION

Table 1.0 Cost and Return Analysis in Yam Production

Item	Unit	Rate	Price/unit	total price(₦)
A.Revenue				
Sales of Yam	1000tubers	5/sett	2500	500,000
Total Revenue	-	-	-	500,000
B. Variable Cost				
Land acquisition(family)	Ha	1.5	15,000	16,500
Labour	Mandays	5	4000	20,000
Yam minisett	250kg	1	33,000	33,000
Fertilizer	25kg/bag	5	5200	26,000
Fertilizer application	Mandays	4	1500	6,000
Staking	mandays	10	1800	18,000
Weeding	mandays	6	1500	9,000
Harvesting	mandays	6	1200	7,200
Miscellanous	-	6	800	4,800
Transportation	manday	-	12000	12,000
C.Total variable cost				152,500
D.Total gross margin				347,500
E.Fixed cost				
Depreciation cost of fixed assets@5% of cost				
Cutlass	-	3	2000	6000
Hoe	-	4	1200	4,800
Rake	-	3	1200	4000
Basin	-	3	1000	3000
Wheel-barrow	-	1	12,000	12,000
F.Total fixed cost	-	-	-	29,800
G.Total Cost	-	-	-	182,300
H.Gross Profit	-	-	-	317,700

Source:Field Survey(2022)

NFI=TR-TC

Where NFI=Net Farm Income

=500,000-182,300

=317,700Return Per Naira invested(RNI) was obtained by dividing the Net Farm Income(NFI) over Total Cost(TC).

RNI=NFI/TC

= 317,000/182,300

=₦1.72

The result reveals that yam production was a viable enterprise as the result obtained revealed a profit of ₦317,700.If you relate it to its benefit cost ratio which means that every ₦1 invested in yam production, there is a return per naira invested of ₦1.72.This means that yam production is a very lucrative agribusiness and may need more participants to increase the quality and quantity of products produced in a year. This is in line with the findings of Jonathan and Anthony,(2012) yam production was a very lucrative business in Nigeria.

Table 2.0:Multiple Regression estimates of the factors that affect the output of yam production

Variables	Linear	Semi-log	Exponential +	Double log
Constant	121.2089	4.250823	1.31	2.947787
	(2.06)**	(5.86)*	(0.04)***	(3.34)**
X_1 Gender	-.691176	-.0245758	-1.59	-4484261
	(-0.09)***	(-0.25)***	(-0.01)***	(-1.37)***
X_2 Age	-13.3353	-.0991438	2.19	-1304137
	(-2.20)***	(-1.33)***	(1.55)**	(-0.50)***
X_3 Farm size	-11.30992	-.1072181	1.76	-.3295775
	(-3.50)***	(-2.69)***	(0.40)***	(-1.54)***
X_4 Farm Exp	16.42947	.1507788	-6.01	.4634215
	(2.96)**	(2.20)***	(-1.82)***	(2.01)**
X_5 Extn Visit	-7.355324	-.0461937	5.25	-.0535276
	(-1.73)***	(-0.88)***	(0.05)***	(-0.36)***
X_6 Labour	26.46915	.3239685	6.38	1.371491
	(3.57)**	(3.54)**	(0.03)***	(4.76)**
X_7 SeedYams	-7.686563	-.0963861	6.35	-.2314577
	(-2.26)***	(-2.30)***	(-0.06)***	(-1.22)***
X_8 AgroChem	15.2896	-.1548827	4.32	-.3877813
	(-3.44)***	(-2.82)***	(0.43)***	(-2.35)***
X_9 H/holdsize	-10.16667	-.1081498	4.98	-.2248548
	(-2.70)***	(-2.33)***	(0.70)***	(-1.57)***
X_{10} Edu Level	19.04682	.184521	1.07	.9191298
	(5.83)*	(4.58)**	(1.00)***	(4.27)**
R^2	0.650	0.637	0.743	0.657
Adj R^2 value	0.607	0.593	0.712	0.616
F-ratio	14.300	14.451***	14.884 ***	0.14837 ***

Source:Field Survey,2022

***Significant at 1%,** significant at 5%,* significant at 10%, + indicates lead equation while figures in parenthesis are the t-ratios.The regression estimate of the determinants of the factors that affected the output of yam farmers is presented in table 2. The coefficient of age was positive and statistically significant at 5%. The age of the farmer had a positive and fundamental impact in yam production. The coefficient for farming experience was negative and significant at 1% level of probability. This is against a prior expectation. If there is increase in farmers farming experience this should lead to an increase in their output.The coefficient of extension visit was positive at 1%, the more contact farmers have with the extension agents and the more likely they are to adopt improved practice..Seeds, labour and Agro-chemicals(farm inputs) were positively signed and statistically significant at 1% level of probability. This implies that the more farm inputs the farmers utilizes, it's more likely that it will lead to increase in their output in yam production.There was a positive relationship between household and output of yam.This is particularly so in view of the increasing cost of hired labour and the inability of the farmers to make use of improved mechanical tools either due to high cost or relative small nature of farm sizes.There was a positive relationship between farm size and output of yam produced. This implies that women farmers who had relatively large farm sizes had more output and revenue. According to Onyebinama and Onyejelem(2010),a larger farm size should translate into greater output and higher revenue generation.

Table 3 Constraints in Yam Production

Constraints	Mean Score	Decision
Lack of fertile land	2.12	Accepted

Limited yam minisett	2.15	Accepted
High cost of labour	2.47	Accepted
Pest and diseases attack	2.83	Accepted
Lack of accessibility to market	2.12	Accepted
Inadequate storage materials	1.76	Rejected

Source:Field Survey,2022

The constraints in yam production among the farmers were analysed using likert scale.The table 3 shows the mean scores were defined to propose that if the values were 2.0 and above ,it should be accepted, but if the value of the mean score is below 2.0,it should be rejected.The result reveals that lack of fertile land has a mean score of 2.12(accepted), limited yam minisett had mean score of 2.15(accepted),high cost of labour was the highest mean score of 2.47(accepted),lack of accessibility to market has a mean score of 2.12(accepted)

CONCLUSION

The benefit cost ratio which gave ₦1.72 revealed that yam production is a very lucrative business and will need more participants in order to increase the quality and quantity of products produced in every farming season.The study also revealed that age,extension visits,household size and farm size were positively signed and had a significant impact to yam production.Furthermore pest and disease attacks,high cost of labour and lack of accessibility to market were major constraints affecting the production of yam by farmers.

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Impact of energy consumption and agricultural production on carbon emission: Evidence in Nigeria

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ABSTRACT

Agricultural activities contributed significantly to carbon emissions and global warming, which in consequence jeopardize efforts to sustainable food production. This study therefore examined the impact of energy consumption and agricultural production on carbon emission evidence in Nigeria between 1971 and 2019. Cointegration and ARIMA models were used to analyze the data. The result shows that there is a long-run relationship between carbon dioxide (CO_2) emission and agricultural activities. ARIMA result shows that electric power (ECE) and fossil fuels (ECF) which were energy consumption in the model are statistically significant at 1% and have negative and positive effects on CO_2 emissions respectively. The study therefore recommended that renewable energy such as hydropower, wind, solar and biomass energy should be used as an alternative to fossil fuels; and minimum or zero tillage, indiscriminate bushes burning, deforestation and encroachment into forest lands reserved for wildlife conservation should be practiced.

Keywords: *Agricultural sustainability; CO_2 emissions; Crop and livestock; ARIMA; Energy consumption; Nigeria*

INTRODUCTION

In most recent decades, change in climatic factors and global warming has become an imperative and pressing matter of concern for the policy and decision makers. The atmosphere concentrations of carbon dioxide (CO_2) are rising annually at about 0.5% due to fossil fuel combustion, particles from cement production and variation in carbon sequestration initiated through the use of land (Mohamad *et al.*, 2016).

Carbon emission results in the combustion of carbon including the fossil fuels, subsequent to the production of CO_2 and incorporating it into the atmosphere, stated as emissions of greenhouse gases. Carbon dioxide emissions ensuing from the ignited fossil fuels such as petroleum oil products and coal are detrimental to agricultural production as they pose risk to global climate changes (Gün, 2019). The determinant factors that influence carbon dioxide emissions include: economic growth, increasing population growth, energy consumption, activities leading to deforestation and per capita national income.

According to Ritchie (2017) livestock occupies about 80% of the universal agricultural land, and still outputs from livestock are below 20% of global source of calories. Mourão and Domingues Martinho (2017) studies in Portugal reported that the increase in the production levels of the livestock and the main typical animal production was significantly heightened by the level of carbon dioxide in Portugal. Appiah *et al.,* (2018), and Hongdou *et al.,* (2018) also reported that agricultural production is significantly and directly correlating with change in climatic factors. Hence, we examined the impact of energy consumption and agricultural production specific determinants (agricultural land use, crop and livestock production) contributions to carbon emissions.

Several studies (Hongdou *et al*., 2018; and Appiah *et al.*, 2018) on the implication of agricultural production on carbon emission utilized agricultural production, FDI, renewable energy, global trade, energy consumption and income per capita as independent variable factors in determinants model of climate change, while some focused on the evaluation of climate change on the theory of Kuznets environmental curve (Och, 2017). However, there exist some studies that assessed the impact of agricultural production directly on carbon emissions (Hongdou *et al*., 2018; Appiah *et al.*, 2018; and Leitão, & Balogh, 2020). In the same way, this study adopted similar approach with emphasis on Nigeria carbon emissions as studies of such are scarcely available in the knowledge vault of Nigeria literatures.

Hongdou *et al*. (2018) used Granger causality, Cointegration, and Vector Error Correlation Model (VECM) and reported that crop productivity has positive effect on climate change, and fertilizer applications was positively correlated with carbon emissions. Appiah *et al*. (2018) used Ordinary Least Square (OLS) and Fully Modified Ordinary Least Square (FMOLS), and reported that energy consumption was negatively correlated with carbon emissions, while population, income per capital, crop and livestock productivity had direct effect on climate change. While Leitão and Balogh, (2020) concluded that agricultural operations and energy consumption had positive effect on environmental pollution, using Autoregressive Distribution lag (ARDL), Granger causality and ARIMA model. Therefore, this study explored the impact of energy consumption and agricultural production on carbon emission in Nigeria. The study examined the correlation and contributory effects of climate change and agricultural production calculated by CO_2 emissions, agricultural land, and crop and livestock production index from 1971 to 2019 in Nigeria. This study will also, fill the existing knowledge gap, serve as a tool to share essential information on the industry, and refocus attention on the prospects of an environmentally friendly agricultural production system.

METHODOLOGY

This study analyses the Nigeria agricultural production factors (crop production, livestock, and agricultural land), as well as energy consumption on climate change between the periods, 1971 to 2019. The study used secondary data extracted from World Development Indicator (WDI) and Food and Agriculture Organization (FAO) database. Johansen Cointegration, and AutoRegressive Integrated Moving Average (ARIMA) model used in this study. Carbon emissions represent climate change. The independent variables selected for this study are: energy consumption from both electric power (ECE) and fossil fuels (ECF), Crop Productivity Index (CPI), Livestock Productivity Index (LPI), and Agricultural Land used (AGL). Adapted from empirical studied of (Hongdou *et al.*, 2018; Appiah *et al.*, 2018; and Leitão, & Balogh, 2020) the equation below established the function as;

$$CO_2 = f(ECE, ECF, CPI, LPI, AGL) \quad (1)$$

In logarithm form as;

$$LnCO_2 = \alpha_0 + \alpha_1 LnECE + \alpha_2 LnECF + \alpha_3 LnCPI + \alpha_4 LPI + \alpha_5 AGL + \mu_t \quad (2)$$

Where; CO2 is carbon dioxide emissions (kt); ECE is electric power consumption (kWh/capita); ECF is fossil fuel energy consumption (kg of oil/capita); CPI is crop production index; LPI is livestock production index (proxy of meat and milk from all sources, cheese, eggs, honey, raw silk, wool, and hides and skins); AGL is agricultural land (proxy of arable, under permanent crops, and under permanent pastures); and u_t is the error term. The data were analyzed using GRETL statistical software. The following hypothesis was tested;
Ho1: Agricultural productivity positively related to climate change via carbon dioxide emissions in Nigeria.

RESULTS AND DISCUSSION

Table 1: Unit root test: Augmented Dickey-Fuller (ADF) test intercept and trend

Variables	**At Level**		**First Difference**	
	Statistic	***P*-value**	**Statistic**	***P*-value**
$LnCO_2$	-2.884	0.181	-5.427	0.000
LnECE	-0.346	0.088	-8.996	0.000
LnECF	-2.620	0.274	-5.592	0.000
LnCPI	-1.531	0.807	-7.954	0.000
LnLPI	-1.324	0.872	-9.690	0.000
LnAGL	-1.742	0.720	-8.204	0.000

Significant at *** 1%
Source: Authors computation, 2022

Table 1 shows the unit root test using ADF intercept with trend. All variables are non-stationary at level and stationary at first difference. Also, all the variables at first difference are statistically significant at 1% level (P-value < 0.01). This implies that all the variables considered are integrates of order *I(1)*. This result agrees with the finding of Leitão and Balogh (2020) in their study in Portugal.

Table 2: ARIMA

Variables	**Coefficient**	**Std. error**	**z**	***p*-value**
Constant	0.0095	0.0229	0.4195	0.6748
phi_1	-0.4216	0.2191	-1.925	0.0543*
theta_1	0.9999	0.4087	2.446	0.0144**
LnECE	-0.2941	0.1059	-2.776	0.0055***
LnECF	1.8024	0.4617	3.904	0.0000***
LnCPI	0.1567	0.0944	1.659	0.0971*
LnLPI	0.0398	0.4075	0.0977	0.9222
LnAGL	0.1165	1.7580	0.0663	0.9472
Mean dependent var		0.0190	S.D. dependent var	0.0920
Mean of innovations		0.0004	S.D. of innovations	0.0554
R-squared		0.6299	Adjusted R-squared	0.4993
Log-likelihood		34.1743	Akaike criterion	−50.3486
Schwarz criterion		−39.7462	Hannan-Quinn	−47.5358
	Real	**Imaginary**	**Modulus**	**Frequency**
AR: Root 1	-2.3720	0.0000	2.3720	0.5000
MA: Root 1	-1.0000	0.0000	1.0000	0.5000

***, **, and *are significant at 1%, 5% and 10% respectively.
Source: Authors computation, 2022

Table 2 shows the ARIMA result of the model. The coefficient of multiple determination (R^2) shows that 63% magnitude of CO_2 were explained by the independent variables included in the model, while Adjusted R^2 0.499 illustrates the correct measurement of the model. ECE and ECF which represented energy consumption in the model are statistically significant at 1% and have negative and positive effects on carbon emissions. This agrees with Tan and Tan (2018). Correspondingly, Leitão and Balogh (2020) affirmed that energy consumption, particularly energy consumption from fossil fuels energies increases CO_2 emissions and as result heightens and worsens the climate change. On the other hand, agricultural land (AGL) and livestock production index (LPI) were insignificant contributors to carbon emissions. This finding is in contrast with Hongdou *et al*., (2018); Appiah *et al*., (2018); and Leitão and Balogh (2020) who reported significant role of livestock production and agricultural land via carbon emissions on climate change.
Test of ARCH (P(chi-square (1) > 1.334) = 0.248) and test of normality of residual (chi-square (2) = 0.927), are significant, thus shows the reliability of the model used in the study.

Table 3: Johansen cointegration

Eigenvalue	**Trace test**	***P*-value**	**Lmax test**	***P*-value**
0.970	191.39	0.000	80.72	0.000
0.853	110.67	0.000	44.17	0.001
0.682	66.50	0.000	26.34	0.069
0.642	40.16	0.002	23.65	0.019
0.340	16.51	0.033	9.54	0.249
0.261	6.97	0.008	6.97	0.008

Significant ** at 5%
Source: Authors computation, 2022

Table 3 shows Johansen Cointegration test using the decisive factor of trace and lmax test techniques. According to the test, the hypothesis of no cointegration was rejected at 5% level of significance. The result agrees with the findings of Leitão and Balogh (2020). This means that there is a long-run relationship between CO_2 emission and agricultural activities.
[

Diagnostic Test

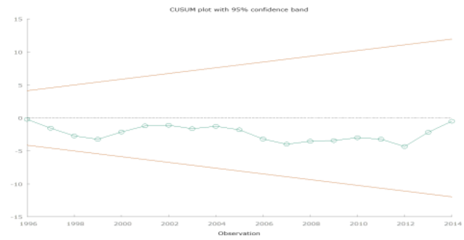

Figure 1: CUSUM Test

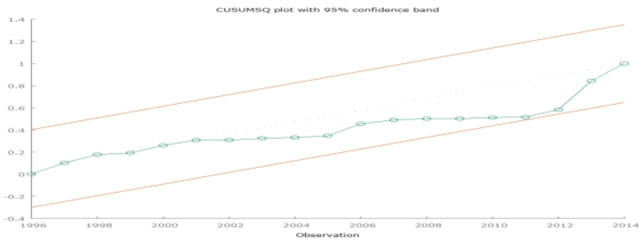

Figure 2: CUSUMSQ Test

Source: Authors computation, 2022

Figure 1 and 2 shows the robustness of the OLS residual, the cumulative sum control chart (CUSUM) and cumulative sum control chart of the square (CUSUMSQ) testing methods were used in this study. Since the broken lines of the data collected shaped by the CUSUM and CUSUMSQ do not extend beyond the boundary at 5% level of significance, then it implies that models used in the study accurately represent the data used in analysis.

CONCLUSION AND RECOMMENDATIONS

This study examined the relationship between Nigeria CO_2 emissions and agricultural activity, energy consumption, using ARIMA and Cointegration for the period of 1971 to 2019. ADF unit root test established that the variables employed in this study were stationary at difference in *I(1)* order. ARIMA result shows that energy consumption (ECE and ECF) are significantly contributing to CO_2 emissions in Nigeria. The indicates that increase in agricultural production activities and energy consumption would result in excessive emissions of CO_2 to the extent of hampering the environment and increasing the already saturated risk propensity in agricultural practice. On the contrary, the resulting increase in food production relates to economic growth. The study, therefore recommended that;

i. In order to minimize the hazards associated with climate change through CO_2 emissions and achieve as well as maintain the sustainability of agricultural productivity, energy from fossil fuels should be substituted with the renewable energy sources like hydropower, wind, biomass, solar energy among others;
ii. Minimum or zero tillage to reduce deforestation, reduction of indiscriminate bush burning for agriculture, incorporating agro-forestry practices into agriculture by planting trees as wind breakers, forest conservation and prevention of urban encroachment into the forest lands apportioned for agriculture and reserved for wildlife conservation should be practiced and enforced; and
iii. Organic farming which is an alternative means to enhance sustainable agricultural practices by minimizing environmental pollution in farming should be adopted.

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Impact Of Financial Inclusion On Rural Livelihood: Evidence From Kwara State Nigeria

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ABSTRACT

In recent times, there have been several efforts to achieve sustainable development and increase people's welfare. Financial inclusion has become the policy agenda of many countries especially in developing economies. Therefore, the effect of financial inclusion on welfare outcomes of people living in rural setting in Nigeria where majority of the populace reside has become very important and is therefore, the subject of this study. Hence, this study empirically examines the impact of financial inclusion on rural economy in Kwara State, Nigeria. Primary data was solely used for the study. A two staged sampling techniques was used for the study. A total of 360 respondents comprising of 180 beneficiaries and 180 non beneficiaries of the VADI scheme across the nine (9) communities where VADI operates in Kwara State. A structured questionnaire was used for the purpose of extracting needed information from the respondents. The data collected was analyzed with descriptive statistics, Double hurdle model, food security index and Propensity Score Matching (PSM). However, the results showed that utilization of credit facilities under VADI Scheme is significantly affected by remittance received, monthly income, membership of cooperative society, functional bank account and number of dependents The result also showed that about 70.5% and 50.9% of VADI Benefitting and non VADI Benefitting households are food secure respectively. The impact of VADI on the food security of the rural households that participated in the scheme revealed an average increase of 17018.22Kcalorie intake.However, it is recommended that government and non governmental agencies should look into the opportunities presented through financial inclusion for sustainable economic growing and development

Keywords: Rural, communities, food security and households

INTRODUCTION

Access to financial services is significant for development and the achievement of the 2030 Agenda for Sustainable Development as it serves as a mechanism for supporting inclusive economic growth (Jahan et al., 2019). It plays a key role in the functioning of markets and the economy; and contributes to economic and social development. The relevance of financial services for the economy is manifold as it contributes to output, foreign direct investment (FDI) and employment; as infrastructure services it provides valuable inputs for activities in the primary, industrial, and tertiary sectors and for individuals; through banking, securities and insurance services, it facilitate domestic and international transactions, mobilize, and channel domestic savings and broaden the availability of credit for Small and Medium Scale Enterprises (SMEs) and households especially those in the rural areas.

Despite the benefit of access to financial services and the progress in recent years, a crucial gap remains between developed and developing economies. In 2017, 94 percent adults in developed economies had an account with a bankcompared to 63 percent in developing economies. The poor, less educated, youth and women who are mostly in the rural areas tend to be more excluded. Therefore, financial inclusion has become a key policy agenda of many countries, since it can contribute to poverty reduction.

Financial inclusion is the process of extending financial products to the unbanked and vulnerable populace. This enables individuals and businesses to have access to financial services such as deposit, loans, insurance, payments and fund transfer at their convenience; and to meet economic needs. Better still, it is the bringing home of financial services at an affordable cost to the disadvantage group in the society, particularly the low-income and underprivileged (Gwalani & Parkhi, 2014).

Growing financial inclusion has the capability of helping the poor through various channels, including the ability to accumulate savings and access credit that enable them to have diverse consumption patterns; better manage financial risk and deal with uncertainties; and also invest in productive assets (Demirgüç-Kunt et al., 2018).

Lack or poor access to financial services signifies a major obstacle to income opportunities and economic welfare of individuals, especially the poor, women and youth, as well as firms, particularly the SMEs in the informal sector who are credit constrained, as lenders have little information on their performance and credit worthiness, as many do not have bank accounts to run their business.

The Village Alive Development Initiative (VADI) was initiated by Agricultural and Rural Management Training Institute (ARMTI) as an action-oriented research with the aim of increasing rural livelihood which encompasses farmer's capabilities, assets, income and activities required to secure the necessities of life in rural communities. In Kwara state, VADI activities covers Idofian, Elerinjare, Jimba-oja and Kabba-owode (ARMTI, 2013).

The study accessed the impact of (VADI) credit services on the livelihood of rural dwellers in Nigeria. The objectives are to

- assess the heterogeneity in financial service credit utilization in terms of rural dwellers characteristics;
- determine the food security status of households in rural communities; and
- examine the impact of financial service under VADI schemeon food security of rural dwellers.

METHODOLOGY

Study Area

The study was carried out in North Central, Nigeria. North Central Nigeria consists of six states, namely Plateau, Nasarawa, Benue, Kogi, Niger and Kwara as well as the Federal Capital Territory, Abuja (National Bureau of Statistics, 2012). The region covers a land area of about

298,830 square kilometres which accounts for 37 percent of the total land area of Nigeria; it hasa population of about 29,252,408inhabitants (National Population Commission, 2016) and has a high degree of ethnic diversity. The region is bounded in the East and West by the republics of Cameroon and Benin respectively and in the North and South by the Northern and Southern states of Nigeria (Okpeh, 2008). This region is an area with certain climatic coherence, stretching over two distinct ecological zones namely; the Savannah zone and the Rain Forest zone. The predominance source of livelihood in the area is farming.

VADI programme is currently in operation in three states in the region namely: Kwara, Benue and Nasarawa States.

Data and Sampling Techniques

The study employed a cross sectional research design. A two-staged random sampling was used for the study. The first stage was the random selection of Kwara Statefrom the three (3) states under VADI programme in North central, Nigeria;and the second stage was the selection of 360respondents comprising of 180 beneficiaries and 180 non beneficiaries of the programme across the nine (9) communities where VADI operates in Kwara State.The sampling frame used for selecting beneficiaries of the scheme was the complete list of farmers obtained from VADI office in each of the communities in the state under the Agricultural and Rural Management Training Institute (ARMTI).

Analytical Techniques

Descriptive Analysis

Descriptive statistics which comprises the use of measures of central tendency and dispersion (mean, mode, median and standard deviation), percentages frequency and tabulation was used to capture the socio-economic characteristics.

Double Hurdle model

Double hurdle model was used to analyze drivers of the decisions of rural dwellers to access financial services and determinants of quantity/amount utilized. Drivers of usage decision ofVADI credit is specified using the Probit model

$Z_I^* = \alpha X_i + U_i$; where Z^* is an unobserved latent variable determining a household's decision to use credit, X is a vector of the characteristics hypothesized to affect the usage decision, and u is the random disturbance term distributed with mean 0 and variance 1.

$Z^*=1$ *if* $Z^*>0$, (for users of VADI credit) ; $Z^*=0$ *if* $Z^*\leq 0$, (for non-users of VADI credit) .

The determinants of amount of VADI credit used was analyzed using a Tobit regression equation given as $Y_i = \beta_0 + \beta_1 X_i + \beta_2\lambda + u$; $Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10,} u)$ Where Y = Quantity of VADI credit used (naira) X_1 = Number of dependents ; X_2 = Gender ; X_3 = marital status ; X_4 = Monthly income (Naira) X_5 = Education (years spent in school) ; X_6 = Age ; X_7= membership of cooperative society ; X_8= Having operational bank account ; X_9= Remittance (Naira) ; U = Error term

Food Security Index

The food security (Z) index as applied by Fakiyesi (2001) is given by the formula $\mathbf{Z}=\frac{Yn}{R}$: where Yn is the nth household's daily per capita calorie intake and R is the recommended per capita daily calorie intake. Thus, Zn=1 for Yn>1 (i.e. food secure households) and Zn= 0 for Yn< 1(i.e. food insecure households). $\mathbf{H}=\frac{M}{N}$: where **H** is the headcount ratio, **M** is the number of insecure household and **N** is the total sample. The nutrients content of both produced and purchased food items were used to derive calorie availability. A daily recommended level of 2470kcal per capita and 65g protein per day defines the food security line, used in this study (Omotesho, Adewumi, & Fadimula, 2007).

Propensity Score Matching (PSM)

Propensity Score Matching (PSM) was used toevaluate the impact of access to VADIfinancial services (credit access) on the welfare (food security) of rural dwellers. PSM addresses the differences in groups prior to treatment by reducing the total collection of observed pre-treatment covariates into a single composite score that is then used to create a comparison group that is similar to the treated group with respect to observed covariates using the propensity score.

The average treatment effect on the treated (ATT) can be estimated using these results. $ATT = E\ Y_1(\ |D=1) - E\ Y_0(\ |\ D=1)$ The CIA implies $E\ Y_0(|\ D=1, X) - E\ Y_0(|\ D=0, X)$; $E\ Y_0(|\ D=0,\ X) - E\ Y_0(\ |D=0,\ p(X))$ Combining these results, the Law of Iterated Expectations can be used to show that $ATT = E\ Y_1(|\ D=1) - E\ Y_0(\ |D=1)$
$= E_p(x)\ |D{=}1\ E\ Y_1(|\ D=1, p(X)) - E\ Y_0[\ (|\ D=0, p(X))]$

RESULTS AND DISCUSSION

Socio Economic Characteristics of Farmers

The socio-economic characteristics of respondents considered in the study include sex, age, marital status, level of education, marital status, number of dependents, farming experience, farm size and primary occupation. The study revealed that most (77.2%) of the farmers in the study area are males, this implies that majority of the households were headed by males.The result showed that the average age of household head in the study area was about 53 years while the majority (34.7%) of the respondents fall within the age brackets of (46-55) years, this suggests that majority of the households heads were in their active age. Majority (59.5%) had at least primary education. This implies that the rural households are enlightened and may be willing to adopt innovations that would bring about increase in their economic activities to improve their income and food security. Results from the study revealed that only 16.6% of respondents were single.

The majority (66.6%) of the household heads had farming as their primary source of income while 76.7% of the farmers had above 10years experience of farming in the study area.

Table 1: Socio-Economic Characteristics of Rural Dwellers

Characteristics	Category	Frequency	Percent
Sex	Female	82	22.80
	Male	278	77.20
Age	<35	15	41.6
	36-45	68	18.00
	46-55	125	34.72
	56-65	72	20.00
	>65	53	14.72
Education Level	No formal	98	27.2

	Non formal	46	12.8
	Primary	110	30.5
	Secondary	97	26.95
	Tertiary	9	2.50
Marital Status	Single	60	16.6
	Married	224	62.4
	Divorced	44	12.2
	Widowed	32	8.8
Household Size	≤ 5	131	36.6
	6-8	128	35.5
	9-11	89	24.7
	>11	12	3.3
Farming Experience	≤ 10	84	23.3
	11-15	138	38.4
	16-20	72	20.0
	21-25	50	13.8
	>26	16	4.5
Farm Size	≤ 1	48	13.3
	1.1-2	98	27.2
	2.1-3	164	45.5
	3.1-4	26	7.2
	4.1- 5	24	6.6
Primary Occupation	Farming	240	66.6
	Artisan	42	11.6
	Trading	48	13.3
	Civil servant	30	8.3

Source: Field Survey 2022

Factors that determine farmers' decision to utilizeVADI **credit facility and amount of credit utilized**

The farmers' decision to access and utilizeVADIcredit was tested. Four out of the nine explanatory variables tested were significant in explaining the farmers' decision to utilize of VADI credit. Remittanceand monthly income were significant at 5% and contributed negatively to dwellers' decision to utilize VADI credit while membership of cooperative society,functional bank account and Number of dependent had a positive relationship with farmers' decision to utilize the credit obtained through VADI and were significant at 5% and 10% respectively.

TABLE 2: Double Hurdle Results for the Factors Influencing VADI credit accessed and the amount utilized by Rural Dwellers.

Variable	Target Equation Coefficient	Std.Error	P>|Z|	Selection Equation Coefficient	Std.Error	P>|t|
Dependent	-0.24309	0.01643	0.010**	0.00893	0.12458	0.852
EducLevel	-0.04110	0.21772	0.823	-0.23651	0.31473	0.628

Gender	-0.02470	0.01403	0.673	0.38701	0.08702	0.001***
marital status	0.36315	0.43121	0.112	1.04104	1.14307	0.410
Monthly income	-1.32e-01	2.4e-04	0.017**	-4.16e-04	0.000012	0.628
Age	1.27330	0.94241	0.020	4.23823	1.18136	0.001***
cooperative society	0.45e-03	3.10e-07	0.057*	4.15e-06	1.36e-06	0.001***
operational bank account	-0.20296	0.53114	0.052*	-0.22543	1.02818	0.872
Remittance	0.02122	0.01011	0.041**	-0.04821	0.04305	0.0302**
Constant	-0.19405	0.12959	0.705	-1.23563	1.60061	0.342
Sigma				3.4194	0.24019	

Note: *, ** and * = Figures significant at 1%, 5% and 10% significant levels respectively.**
Source: field survey data, 2022

Table 4 presents the households food security status of VADI Beneficiaries and Non- VADI Beneficiaries. About 70.5% and 50.9% of the VADI Benefitting and non VADI Benefitting households were food secure respectively. The mean daily energy and protein available to the food-secure households for VADI Beneficiaries and non VADI Beneficiaries are (17018.22Kcal and 346.41g) and (16015.26Kcal and 331.71g) respectively while the daily per capita energy for food secure households for VADI Benefitting and non VADI Benefitting households are 3550.50kcal and 2950.05kcal respectively.

Table 3: Food Security Status of Rural Dwellers

	VADI Beneficiaries		Non- VADIBeneficiaries	
	Food Secure	Food Insecure	Food secure	Food Insecure
Household Percentage	70.5	29.5	50.9	49.1
Mean Adjusted Household Size	4.72	4.89	5.30	5.71
Household daily energy availability (Kcal)	17018.22	11446.70	16015.26	10402.71
Household daily per capita energy	3605.55	2340.84	3021.75	1821.84
Household daily protein availability (g)	346.41	274.16	331.71	234.70
Household daily per capita protein availability	73.39	56.07	62.59	41.10
Head Count Ratio	0.705	0.295	0.509	0.491

Source: Field survey, 2022

Table 4 reveals that Average Treatment Effect on the Treated (ATT), which measures the impact of VADI on food security of households that Benefitted, showed that the calorie intake increased on the average by 1176 kcal/AE/day. The increment in the calorie intake of the Beneficiaries was significant at 1%. Average Treatment Effect of VADIon the Untreated (ATU) showed that if the non- beneficiaries had utilized thescheme, the improvement in their calorie intake would have been increased by 1089kcal/AE/day while Average Treatment Effect (ATE) shows that if a respondent was to be picked randomly, the calorie intake would increase by 1092 kcal/AE/day, since ATT is greater than both ATU and ATE, it implies that VADIhas impact on the food security of the households benefitting.

Impact of Irrigation Scheme on Calorie Intake of Farming Households

Table 4: Treatment Table

Variable	Sample	Treated	Control	Difference	S.E.	T-Stat
Farm Income	Unmatched	1847.657	972.612	875.045	5572.834	3.64***
	ATT	2281.790	1105.476	1176.314	7261.763	3.85***
	ATU	1965.576	876.079	1089.497	-	-
	ATE			1092.446	-	--

Source: Field Survey, 2022**;** *, **, *** indicate the coefficients are statistically significant at 10%, 5% and 1% level respectively. T-values are based on Bootstrapped standard error.
ATT is Average Treatment Effects on the Treated, ATU is Average Treatment Effect on the Untreated and ATE is Average Treatment Effects.

CONCLUSION AND RECOMMENDATION

From the empirical evidences of this research work, it clear that VADI scheme which is a form of financial inclusion of great impact on food security of rural communities. However, it is recommended that government and non governmental agencies should look into the opportunities presented through financial inclusion for sustainable economic growing and development

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Increasing Yam Production And Food Security Through Utilization Of Yam Technologies

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ABSTRACT

The study reviewed the significance of utilization of yam technologies to increase yam production and achieve food security in Nigeria. Secondary data were used for the study. Yam plays a very important role in ensuring food security and livelihood systems of people living in Nigeria. The major uses of yam are for human consumption, income generation, and for social, cultural, or religious events. One of the ways small holder yam farmers can achieve sustainability and food security in yam production is by improving their efficiency within the input of existing resource base and technology. Yam production technologies include improved yam varieties, yam mini-set technique, land preparation, appropriate spacing, weed control, fertilizer application, improved staking, and proper harvesting time. The reviewed study concluded that the effective utilization of yam technologies developed and released in Nigeria for yam production have the attributes or characteristics that will promote food security. Major constraints to yam production include access to credit and high production cost. It is recommended that, in order to increase yam production and achieve food security, the effective utilization of yam technologies developed and released by research institutions (IITA Ibadan and NRCRI Umudike) will be maximally utilized by yam farmers

Key words: **Food security, Utilization, Yam Technologies and Yam Production.**

INTRODUCTION

Yams (Dioscorea species) constitute the predominant starchy staple in sub-Saharan Africa where food security for a growing population is a critical issue, Regina *et al.* (2011). According to FAO (2014), the world output of yam is estimated at 68.1 million tones on a total cultivated land area of 7.8 million ha, corresponding to an average yield of 8.8 t/ha. Nigeria is the largest producer of yams with about 45 million tonnes in 2014, representing 66 percent of world output. The most cultivated species of yam (Dioscorea sp.) are white yam (D. rotundata), yellow or Guinea yam (D. cayenesis) and water yam (D. alata). Yam plays a very important part in ensuring food security and livelihood systems of at least 60 million people in West

Africa. It is cultivated mostly in the Derived and Southern Guinea Savanna. About 57 million tons of yams (about 93% of global production) are produced on 4.7 million hectares annually in this sub-region, mainly in five countries namely; Benin, Côte d'Ivoire, Ghana, Nigeria and Togo. Nigeria alone accounts for 47 million metric tonnes of global yam production (Vanguard, 2021), Yams are cultivated for mainly seed yam and ware yam production. Ware yams are intended for consumption, while seed yams are the planting materials used in the field production of ware yams (Eyitayo *et al.*, 2010). The major uses of yam are for human consumption, income generation, and for social, cultural, or religious events. It is eaten in different forms such as *fufu* (the so-called poundo yam and Amala in Nigeria), boiled, fried and roasted (IITA, 2009). They are among major cash and most consumed food crops in West African countries like Nigeria (National Bureau of Statistics, 2012). Its cultivation is very profitable despite high costs of production and price fluctuations in the markets (IITA, 2012; Izekor and Olumese, 2010). Yam place in the diet of smallholder farmers cannot be over emphasized. It contributes over 200 dietary calories per capita per day for over 150 million people in West Africa and have over 21% dietary fibre and are rich in carbohydrates, vitamin C, potassium, manganese and other essential minerals (IITA, 2009). Many yam belt areas in Nigeria continuously proclaimed "yam is food and food is yam" (Maikasuwa and Ala, 2013).

In Nigeria, the scarcity and high cost of seed yam has forced the production of ware yam to fall short of the aggregate demand for ware yam for food consumption and industrial uses. Since the restoration of democracy in 1999, agricultural policies have sought to enhance food security and combat poverty and extreme hunger (Ojo and Adebayo, 2012). As a result, mini tuber yam production by smallholder farmers has assumed great importance for increased supply of mini tuber yam (planting material) to seed yam producers in response to the increasing demand for ware yam. It implies that efficient use of farm resources has strong potential for increasing the profit efficiency of the farmers in the supply of planting material to seed yam producers, as well as reflect an increase in farm employment, income and food security in Nigeria. Increase in farm profit efficiency through efficient use of farm resources is an important part of agricultural sustainability (Anyaegbunam *et al.* 2019). One-way small holder yam farmers can achieve sustainability in yam production is to raise their production, by improving their efficiency within the input of existing resource base and technology (Ajibefun, 2004). Expansion and increasing intensification of yam cultivation have raised the need for ensuring a sustainable availability of high-quality seed yam on a commercially viable basis in yam growing areas. An early adopter of YIIFSWA-promoted improved yam varieties enjoyed "fantastic" yield of 32.6 t/ha (Asiedu), 30.0 t/ha (Kpamyo), and 37.5 t/ha (Swaswa) from which he earned reasonable revenue (Amadi, Anyaegbunam and Amadi (2022). To achieve food security, innovative yam propagation techniques have been developed by international Institute for Tropical Agriculture (IITA) and National Root Crops Research Institute (NRCRI) Umudike for yam farmers to increase output and make food available. Therefore, there is need for this study to review how to achieve food security through utilization of improved yam technologies in Nigeria.

Appropriate Technology

Technology is considered appropriate if it makes optimum use of any given economic environment. Aremu *et al*. (2015) stated that appropriate technology for peasant agriculture should comprise the set of objectives or tools that will unlock new resources, increase productivity and generate new capacities to produce goods and services on farms. To ensure that technologies are appropriate to the actual needs of the farmers, it is suggested that agricultural research in Nigeria should emphasize what is now known as participatory research (Nwosu and Nwachukwu, 2013). According to Ann (2013), the appropriate technology integrates and inter connects sub processes which include delivery of the technology to the targeted farmers and promotion of new technology to the region as follows:

- persuading farmers to adopt the technology;
- enabling the targeted farmers to apply the technology in their farms and giving them the knowledge and skill necessary to do so;
- provision of technical application requirement;
- diagnosis and treatment of problems that may arise during the application and dissemination of new technology and;
- the basic requirements that are reliable in choice of agricultural technology for farmers.

Farmers need proper orientation on appropriate technology to scale up their productivity.

Food security concept

Food security has been defined as physical and economic access, at all times to adequate food for an active and healthy life, which includes access to nutritionally safe foods and an assured ability to acquire foods in socially satisfactory ways (Food and Agriculture Organization (FAO), 2012). The concept of food security includes both physical and economic access to address people's needs and preferences. In that way, a household should have the possibility to consider all its members at all times. FAO (2013) enlisted three main steps towards achieving food security such as; food availability, food accessibility, and food utilization. There are however, some major problems associated with food production and consumption. They are among others the availability and suitability of cultivable land, the method of cultivation, the technology and energy productive effort and equitable distribution of available food resources. Nevertheless, Nigeria still has the potentials for food security if the following technologies on yam farming are adopted and utilized;

- Improved yam varieties
- Proper land preparation
- Yam mini-set technique (for seed yam production)
- Appropriate spacing (1mx1m for ware yam and 0.25mx1m for seed yam).
- Weed control (1st and 2nd weeding).
- Fertilizer application.
- Staking of yam vines.
- Proper harvesting time.

(Roots, 2014).

Improved yam varieties released by IITA and NRCRI Umudike and registered in Nigeria

Variety Name	Outstanding Characteristics / Potential yield	Year Released
TDr 89/02677	Stable yield, very good cooking and pounding qualities, cream tuber parenchyma, 25% tuber dry matter content	2001
TDr 89/02565	Stable yield, very good cooking and pounding qualities, cream not oxidizing parenchyma, 35% tuber dry matter content	2001
TDr 89/02461	Stable yield, very good cooking and pounding qualities, cream tuber parenchyma, 26.7% tuber dry matter content	2001
TDr 89/02665 (Asiedu)	Stable yield, very good cooking and pounding qualities, cream non oxidizing tuber parenchyma, 35.3% tuber dry matter content	2003

TDr 95/01924	Stable yield, very good cooking and pounding qualities, white non oxidizing tuber parenchyma, 32.8% tuber dry matter content	2003
DRN 200/4/2	High yielding, pest and diseases tolerant, very good for fufu, frying and boiling suitable for rainy and dry season yam production. 35t/ha.	2008
TDa 98/01176 (Swaswa)	High yielding, pest and diseases tolerant, good for pounding, frying and boiling. 26-30t/ha.	2008
TDa98/01168	High yielding, pest and diseases tolerant, good for pounding, frying and boiling. 24-28t/ha.	2008
TDa 98/01166	High yielding, pest and diseases tolerant, good for pounding, frying and boiling. 26-30t/ha.	2008
TDr 95/19158	High yielding, pest and diseases tolerant, very good for pounding, frying and boiling. 29.4t/ha.	2009
TDr 89/02602	High yielding, pest and diseases tolerant, very good for pounding, frying and boiling. 31.5t/ha.	2009
TDa 00/00194	High yielding, pest and diseases tolerant, good for pounding, frying and boiling. 37.5t/ha.	2009
TDa 00/00104	High yielding, pest and diseases tolerant, good for pounding, frying and boiling. 30t/ha.	2009
UMUDa-4	High yielding, good for Amala, pounded, frying and boiling 33.3t/ha.	2010
UMUDr-17	High yielding under dry season yam cropping system, 30t/ha.	2010
UMUDr-18	High yielding, pest and diseases tolerant, very good for yam fufu, frying and boiling. 31t/ha.	2010
UMUDr-20	High yielding, 39.9t/ha.	2016
UMUDr-21	High yielding, 43.9t/ha.	2016
UMUDr29 (Super)	Tolerance to yam mosaic disease, slow rate of oxidation (browning) and high dry matter content.	2022
UMUDr30	Tolerance to yam mosaic disease, slow rate of oxidation (browning) and high dry matter content	2022
UMUDa31 (Wonder)	Tolerance to yam mosaic disease, slow rate of oxidation (browning) and high dry matter content, high yield, excellent boiling and poundimg quality	2022
TDa1100201	Good boiling, good taste and good dry matter	2022
TDa1100316	Good boiling, good taste.	2022

Source: Amadi, Anyaegbunam and Amadi (2022).

CONCLUSION/RECOMMENDATIONS

The reviewed study concluded that the utilization of the improved yam technologies developed and released in Nigeria for yam production have the attributes or characteristics that promote food security. Major constraints to yam production include access to credit and high production cost. It is recommended that, in order to achieve food security, the effective utilization of improved yam technologies developed and released by research institutions (IITA Ibadan and NRCRI Umudike) such as improved yam varieties, yam mini-set technique, land preparation, appropriate spacing, weed control, fertilizer application, staking of yam vines and proper harvesting time are encouraged to be utilized by yam farmers in Nigeria.

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Capacity Development Of Youths And Women On Catfish Production In Nigeria

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ABSTRACT

Human capacity development on catfish production targeting youths and women in Nigeria was carried out by Nigerian Institute for Oceanography and Marine Research from 2017 to 2020. A total of 1366 people were trained comprising of 949 males and 417 females, selected from six geopolitical zones of Nigeria. The modules taught during the training included the different value chains of catfish production. The training programme on catfish farming, the major fish species cultured in Nigeria has further boasted aquaculture production through engagement and empowerment of youths and women as skilled actors in the fish industry in Nigeria.

Keywords: capacity development, youths, women, catfish production,

INTRODUCTION

Capacity development is the process whereby people, organizations and society as a whole unleash, strengthen, create, adapt, and maintain their affairs to achieve set goals. The way of increasing fish production and ensuring that Nigeria is self-sufficiency in fish production by engaging in fish farming especially catfish farming (Adediran, 2002) and Ugwumba, (2005). This is because currently, we need 3.2 Million tonnes of fish but produce 1.1 Million tonnes leaving a deficit of 2.1 Million tonnes with estimated population 187.1 Million (FDF 2015). Fish contributes a significant amount of animal protein to the diet of many people in Nigeria. It is widely accepted, readily available and relatively cheaper when compared with protein from other animal sources (Ugwumba and Ugwumba, 2003, Gabriel et al, 2007).

The need to increase food security especially animals protein in Nigeria culture is by fishery activities to skyrocket in the third world countries (Akinrotimi *et al,* 2007). Youths and women require education and training on aquaculture production in order to provide them with the knowledge to contribute to national and household food supply, security and income (FAO, 2011).

Food and Agriculture Organization (FAO) reported that increased aquaculture activity is key to meeting the demand for food associated with global population growth, and more and more people, especially in poor rural areas, where food often lacks essential nutrients(FAO, 2014),. Aquaculture is the fastest growing food production sector in the world (Tacon, 2020).

According to FAO (2017, 2017b), implementing sustainable aquaculture is therefore central to achieving many of the sustainable development goals (SDGs). This will directly affects the success of SDG 1 (end poverty. Aquaculture can influence poverty alleviation in two main ways: by increasing income for families and by generating jobs, specifically for very low income or poor people producers. In this way, aquaculture offers an effective mechanism to lift individuals and communities out of poverty for those able to enter the sector (Stevenson; Xavier, 2009)

Youths and women needs education and training on Aquaculture in order to provide them with the knowledge to contribute to greater national and household food supply, security and income (FAO 2011).There was a need to equip women and youths with skills in the aquaculture value chain. The Federal government of Nigeria fashioned out the skill acquisition schemes to empower youths and women and give them means of livelihood in order to reduce the high unemployment rate in the country. In 2016, Federal government in conjunction with Nigerian Institute for Oceanography and Marine Research renewed programme on Aquaculture development for training of unemployment youths and women in Aquaculture and post-harvest technology in the six geopolitical zone (i.e North- East, North-West, North-Central, South east, South-South and South-West). This study sees capacity development of the youths and women as a tool to address the constraints and decline in catfish production in Nigeria, identify the number of men and women trained in the six geopolitical zone and know the total number of youths empower from 2017 to 2020 before outbreak of covid- 19 pandemic.

MATERIALS AND METHODS

This study was carried out in Nigerian Institute for Oceanography and Marine Research records from 2017 to 2020 before the outbreak of covid-19 pandemic. The trainees were accommodated for the period of the training. Each training were conducted between one and two weeks. The training utilizes participatory approach which include lectures (30%) hands on practical works (70%), discussion groups and other interactive learning methods. The trainees were chosen by ADP staff of the states from Federal ministry of Agriculture and rural development. And also the trainees were selected by screening from various local government area from the six geopolitical zone through the programme of capacity development by the senators and house of assembly members in their constituencies. The trainees were trained on Aquaculture production and fish post-harvest technology. The resource persons adopted a combination of lectures, class exercises, use of audio visual materials and mostly use of practical demonstrations to impact knowledge efficiently on the participants. At the end of the training trainees were awarded with certificate for participation and training manual provided. The Institute trained 1,366 out of which male are 949 (69%) and female were 417 (31%) from the six geopolitical zone from 2017 to 2020 before the outbreak of Covid – 19 pandemic. Trainees were evaluated and stated their farm location for monitoring. The trainees also formed a WhatsApp group for easier communication. The results of trainees participated were analyze using IBM SPSS statistics 20 and Microsoft excel 2013.

RESULTS

Table 1: Number Youths and women trained by Nigerian Institute for Oceanography and Marine Research (NIOMR) from 2017 - 2020.

Year	Male	Female	Total	Ratio of male : female
2017	53	18	71	0.75 : 0.25
2018	168	59	227	0.74 : 0.26
2019	665	289	954	0.70 : 0.30
2020	63	51	114	0.55 : 0.45
Total	949	417	1,366	0.69 : 0.31

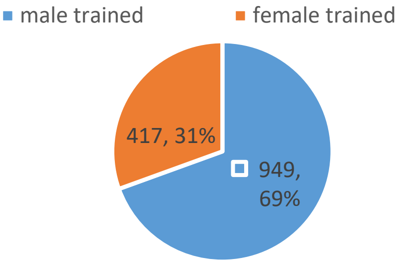

Figure 1: Pie chart indicating Percentage of male and female trained at NIOMR from 2017 to 2020

Table 2: Composition of Starter packs received by trainees from 2017 to 2020

	Quantity	2017	2018	2019	2020
Plastic fish tanks	2	X	X	X	X
Fish feed	35 bags	X	X	X	X
Juvenile catfish	1000	X	X	X	X
Scoop net	1	X	X	X	X
Weighing scale	1	X	X	X	X
Plastic bowls	2	X	X	X	X
Fishing nets cover	2	X	X	X	X
Plastic sieves (for fish sorting of sampling)	2	X	X	X	X
Log book	1	X	X	X	X
Salt (1kg)	1	X	X	X	X
Fish smoking kiln (25kg)	1	N/A	X	N/A	N/A
Knife	1	N/A	X	N/A	N/A

Table size catfish (for smoking)	25kg	N/A	X	N/A	N/A
Charcoal (for smoking of fish)	8.5kg	N/A	X	N/A	N/A

<u>Key</u>

X = provided for the Trainees N/A = Not provided for the Trainees

Plate 1: Distribution of starter packs plate 2: Trainee signing for collection of

to trainee (fish tank, fish feed, tanks, net, starter packs (smoking kiln, scale, knife

Scale, plastic bowls, log book, etc charcoal, table size fish, salt, plastic bowls)

Plate 3: Offloading of starter packs to one Plate 4: Distribution of juvenile fish to one

Of the female trainee the trainee after installing of his fish tank

Plate 5: Training session on fish processing **plate 6: Training section (Fish seed**

(Smoking of catfish) **production**

DISCUSSION

Empowering youths and women on aquaculture production and fish processing through training could go a long way by eradicating poverty and youth's restiveness. The initiative by Federal government aimed at the development of the agriculture sector as well as youths empowerment in order not to be over dependent on the oil sector and youths depending mostly on white collar jobs. Nigerian Institute for Oceanography and Marine Research trained 1,366 out of which male are 949 (69%) and female were 417 (31%) from the six geopolitical zone from 2017 to 2020 before the outbreak of Covid – 19 pandemic (Table 1 and figure 1) . About 43 training programmes were carried out during this period. This programme is in line with the event organize by African development bank (2012) and World Bank (2014). Table 1 showed number of youths and women trained for four years before the outbreak of Covid – 19 pandemic. The lowest number of male and female were observed in 2017. The highest number of male and female were observed in 2019 (Table 1)

Table 2 indicates unemployed Youths and women trained by the Federal government project were supplied with starter packs in order to establish themselves and also in the future to be an employer of labour. The starter packs comprises of rearing tanks ($3m^3$), fish feed, juvenile fish, scoop net, weighing scale (20kg), kitchen knife, plastic bowls, net for covering of tanks, sieves, log book (for record keeping, salt (1kg), smoking kiln (25kg), table size fish (25kg) and charcoal from 2017 to 2020 depending on the training purpose. The aim is to contribute towards increasing employment of youths and women through skill acquisition, re-orientate their minds to be owners of fish farm and employer of labour in the near future. Also the essence of this provision of the starter pack is to increase means of livelihood, employment creation, and revenue generation from generation to generation. This is also corroborate with project organize by FAO (2011C), IFAD (2010) and IFAD (2011). Investment in sustainable production systems for aquaculture is an alternative that should be encouraged to ensure environmental protection that is also economically viable and socially just. (Marques et al, 2020).

Moehl, (2013) states five challenges facing the aquaculture sector (high quality and affordable seed, feed, capital, market and information. These five factors were made easier through capacity development by Federal government and Nigeria Institute for Oceanography and Marine Research with training, technical and management, issuance of starter packs as well as strong financial and business planning. The trainees were provided with high quality juveniles, fish feed, money and WhatsApp group were open in order to monitor and pass information. At the end of the training certificate were awarded to the trainees.

CONCLUSION AND RECOMMENDATION

It is estimated that Nigeria needs to produce at least 700,000 metric tonnes (Winrock International (2010) of fish annually to eliminate its dependency on fish importation. According to Obiya and Ekubo (2011), Government should encourage more involvement in the fish farming business such that will create an enabling environment to increase investment in fish aquaculture development in Nigeria. Development of youths and women in Nigeria through training will promote the benefits of catfish production, increase employment opportunities and source of animal protein for small income earners, reduce food insecurity and poverty alleviation.

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Determinants Of Farmers' Access To Credit In Irepodun Local Government Area Of Kwara State, Nigeria

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ABSTRACT

The study analyzed the determinants of access to credit among farmers in Irepodun Local Government Area of Kwara State, Nigeria. Primary data were obtained from a total of 104 selected farmers in 5 farming communities. Descriptive statistics and ordinary least square regression model were used to analyzed the data. The results revealed that the farmers were within the active and productive age with a mean age of 42years. 90% of the farmers had formal education, 75% were male and the average household size and farming experience of the farmers was 8 persons and 16years respectively. Majority of the farmers' source of finance were personal savings, families and friends and cooperatives. Only about 54% of the farmers have access to credit with an average of ₦416,946.50 obtained. The determinants of access to credit in the area were annual income (6.89), interest rate (5.58), farm size (2.29), membership of cooperative (2.92) and age of the farmer (2.23). The perceived constraints to credit access among the farmers were absence of banks in locality, lack of guarantor, distance from financial institutions, lack of awareness and high administrative procedures among others. The study concluded that access to credit facilities among the farmers in the study area is inadequate. Establishment of credit/loan offices closer to the farmers and operated by officials who would be familiar with farmers in the study area to reduce lending procedures and risks was recommended.

Keywords: Credit access, Farmers, Irepodun LGA.

INTRODUCTION

Small scale farmers are an important contributor to the national objective of creating employment opportunities, generating income and providing a source of livelihood for the majority of the low-income households in the country. However, inadequate credit supply is a central problem upon which other production factors exerts negative influence on farmers' output and productivity (Akinola, 2013; Agada, 2017). Limited access to agriculture credits perpetuates poverty and innovation which the farmers wish to adopt may be too expensive to procure if they have restricted access to credit facilities. Lack of appropriate financial services is one of the major problems experienced by small scale farmers and it is a major constraint to small scale commercialization in developing countries (Obisesan, 2013; Ololade and Olagunju (2013). However, there is a consensus on the fact that to increase the level of food crops production in the country, small scale farmers need to be strengthened financially, as agricultural credit has been cited as being used in developed countries to accelerate agricultural production, implying that inadequate flow of credit into agriculture is a critical factor that is militating against incremental food production in Nigeria. Although successive governments have come up with numerous programs to address the inability of agricultural output to keep pace with the country's demand for agricultural products as argued by Salihu *et al*. (2018). However, credit institutions have over the years shield away from lending to the small-scale farmers who form the larger part of the farming population citing reasons such as high default rates, difficulty in monitoring numerous individuals whose loans do not provide much return on investment as well as not being cost effective (Agada, 2017).

Farmers have continued to record low level of productivity due inadequate capital and limited access to agricultural credit facilities for their production activities (Akinola, 2013; Adewumi *et al.*, 2021). There is little or no evidence of research on determinants of farmers access to credit in Irepodun LGA of Kwara State. Following on the problem of credit access elucidated above, the primary objective of this research was to determine the factors that influence access to both formal and informal credit institutions by the farmers. It is in the light of the above problems that this study attempted to examine the determinants of access to credit by farmers in the area.

This research aimed to contribute to the body of literature on determinants of access to credit finances, the constraints faced by small scale farmers in accessing credit facilities and its effect on economic outcomes. It will bring to fore factors affecting farmers in Irepodun Local Government Area as touching the issue of their accessibility to credit facility. In addition, this study will also contribute to the pool of literature on the role of credit in increasing agricultural productivity as a pathway out of chronic rural poverty and household food insecurity in Nigeria. Furthermore, the outcome of this study would be useful in identifying institutional arrangements that would serve as an input for policy makers in formulating rural credit policy. This study will also serve as reference point or guide to study for those who will carry out similar research work in the study area in the future.

METHODOLOGY

The study area

The study was conducted in Irepodun Local Government Area of Kwara State, Nigeria.

Sampling technique and sample size

A multi-stage sampling was used in selecting farmers from the local government area. The local government is divided into eleven (11) wards. At the first stage five (5) wards were randomly selected out of eleven (11) wards. At the second one (1) village was randomly selected from each of the five wards. At the third stage, following Adewumi *et al.* (2018), 10% of the farmers were proportionately selected from each the villages. This gave a total sample size of 104 for the study.

Method of data collection

Primary data were used for this study. The data were obtained from the respondents with the use of structured questionnaire which was complemented with the interview schedule. The researcher was assisted by trained enumerators. For respondents who could not write or understand English language, the questions were related to them in a language (Yoruba) understood by them through the aid of interpreters and their responses were entered into the questionnaire in English language.

Method of data analysis

Descriptive statistics which include frequency distributions, percentages and mean were used to describe the socioeconomic characteristics of the farmers, identify the source and level of access to credit as well as constraints encountered by the farmers. Also, the ordinary least square (OLS) regression model was used to ascertain the determinants of access to credit among the farmers. The model is implicitly specified as follows:

$Y = f(X_1, X_2, X_3, \ldots, X_9)$

The model is explicitly specified as follows:

$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + e$

Where:

Y = Amount of credit accessed by the farmers (₦)
X_1 = Annual income (₦)
X_2 = Interest rate (%)
X_3 = Farm size (ha)
X_4 = Member of cooperative (member = 1, non-member = 0)
X_5 = Access to extension (number of contacts)
X_6 = Age (years)
X_7 = Sex (male = 1, female = 0)
X_8 = Level of education (years of formal education
X_9 = Farming experience (years)
α = intercept
$\beta_1 - \beta_9$ = Regression coefficients
e = Error term

RESULT AND DISCUSSION

Socio-Economic Characteristics of Farmers

The socio-economic characteristics of the selected farmers which included; age, gender, household size, level of education, farming experience, membership of cooperative and access to extension services were presented in Table 1. The results showed that most of the respondents were within the age range of 21-50 years with the mean age of 42 years which suggests that majority the farmers in the study area were young, active and energetic. This group of farmers could be more productive when given access to adequate capital to expand and boost their production. This result is slightly higher than the average of 37 years reported by Ibrahim *et al.* (2019) for farmers in Niger State.

The results further revealed that majority (75.00%) of the farmers in the area were males. The low percentage of women involved in farming in the area could be as a result of cultural and religious belief which limited the outdoor activities of women. This finding lends credence to the argument of Fadairo *et al.* (2015) that male participation in agricultural production is more pronounced than that of female. Also, results in Table 1 showed that the mean household size of the farmers in the area was 6 persons. This suggests that family labour could be readily available to the farmers which could help them reduce financial cost of production relatively in the area. This could help boost farm income thereby increasing productivity.

Findings in Table 1 showed that about 90% of the farmers had one form of formal education or the other ranging from primary to tertiary level. The relevance of education in agricultural production in the views of Ibeun *et al.* (2018) and Salihu *et al.* (2018) is that high educational attainment can help farmers to produce efficiently and boost their livelihoods. It could also boost farmers' chances of accessing agricultural credit formal financial institutions. Results further showed that a typical selected farmer in the area had an average of 16 years of farming experience. The number of years one has been involved in farming helps to build practical knowledge in agricultural production towards improved productivity.

The findings equally revealed that only 43.23% of the farmers belong to cooperative society. This is relatively low and may limit farmers access to financial services from relevant financial institutions. Unfortunately, results also revealed that majority (89.42%) of the sampled farmers had no access to agricultural extension services. This implies that these farmers may not be aware and exposed to networks and opportunities for securing financial assistance in addition to increased access to timely and adequate information on improved and sustainable farming practices towards efficient crop production.

Table 4.1: Socio-Economic Characteristics of the Farmers

Variables	Frequency (n = 104)	Percentage	Mean value
Age range			42.00
Less than 21	4	3.85	
21-30	20	19.23	
31-40	26	25.00	
41-50	26	25.00	
51-60	13	12.00	
Above 60	15	14.42	
Gender			
Female	26	25.00	
Male	78	75.00	
Household size			6.00
1-5	50	48.08	
6-10	53	50.96	
11-15	1	0.96	
Level of Education			
Adult education	3	2.88	
No formal education	8	7.69	
Primary	14	13.46	
Secondary	29	27.88	
Tertiary	50	48.08	
Farming experience range			16.00
1-10	49	47.12	
11-20	27	25.96	
21-30	11	10.58	
Above 30	17	16.35	
Member of cooperatives			
Member	45	43.23	
No member	59	56.73	
Access to extension service			
Access	11	10.58	
No access	93	89.42	

Source: Field survey, 2021.

Farmers' sources of finance

The sources of finance available for farmers is presented in Table 2. It revealed that majority of the farmers' source of capital were personal savings (86.56%) and families and friends

(70.19%). This is an indication that most of the farmers don't have access to formal financial institutions where they can obtain borrowed capital for their farm operations. It also suggests that personal savings and families and friends has helped farmers in the study area in securing capital to facilitate their farming business in the absence of formal credit. Although, results revealed that some got credit from cooperatives (58.65%) and micro-finance banks (25.00%), this is not enough. Local money lenders, nongovernmental organizations and commercial banks were the other source of credit recorded among the farmers. This finding suggests that inadequate access to agricultural credit remains a major issue of concern among farmers in the area and Nigeria as a whole.

Table 2: Sources of finance

Source of savings	Frequency	Percentage
Personal savings	90	86.56
Families and friends	73	70.19
Cooperatives	61	58.65
Micro-finance banks	26	25.00
Local money lenders	5	4.80
Non-governmental organizations (NGOs)	4	3.84
Commercial banks	2	1.92

Source: Field Survey, 2021

Farmers' Access to Credit

The farmers' access to credit were analyzed which include: access to credit, range of amount obtained and summary of the amount obtained as stated in Table 3. Results revealed that 53.85% of the farmers had access to credit in the study area. Which connote that reasonable percentage of farmers still does not enjoy credit facilities in Irepodun Local Government Area. Findings also revealed that 20.19% of the farmers in the study area were able to access from between ₦1.00 to ₦250,000.00, 19.23% accessed between ₦250,000.00 to ₦500,000.00 Naira while 14.42% were able to access above ₦500,000.00. Table 4.3 further revealed that those who had access to credit obtained an average of ₦416,946.50 in the study area.

Table 4.3: Level of Access to Credit

Access to credit	Frequency	Percentage
Access	56	53.85
No access	48	46.15
Total	**104**	**100.00**
Range of amount obtained (₦)		
1.00 – 250,000.00	21	20.19
250,000.00 – 500,000.00	20	19.23
Above 500,000.00	15	14.42
Zero	48	46.15
Total	**104**	**100.00**
Mean	**416,946.50**	

Source: Field Survey, 2021

Determinants of access to credit by the respondents in the study area

The OLS regression estimate of the determinants of access to credit is presented in Table 4. The F-ratio of 37.88 which was significant at 1% level of probability implies that the model has a strong explanatory power. The result shows that the coefficient of multiple determination represented as R-square indicated that the independent variables in the model explained a significantly high percentage (about 78.39%) of the total variation in the amount of credit accessed by the farmers. The result shows that the coefficients of annual income at 1%, interest rate at 1%, farm size at 5% and membership of cooperative at 1% levels of significance respectively were positive and statistically significant. This implies that the variables significantly determine farmers access to credit in the study area. Given they were positive, it also implies that an increase in these variables will increase the chance of the farmers getting more access to credit in the area. On the other hand, age of the farmers was negative and significant at 5% level of significance. This implies that as the farmers get older, the chance of getting access to credit reduces. This result is similar to those of Ololade and Olagunju (2013) and Obisesan (2013) who reported that income, age, land area cultivated, membership of farmers group and rate of interest are major factors influencing farmers access to credit in Nigeria.

Table 4: Determinants of farmers' Credit Access

Variables	Coefficient	Standard error	t-value	p-value
Annual income	0.24	0.04	6.89***	0.000
Interest rate	3249.55	581.92	5.58***	0.000
Farm size	23536.86	10275.51	2.29**	0.024
Member of cooperative	22944.86	7860.15	2.92***	0.004
Access to extension	439.98	711.57	0.62	0.538
Age	-372.47	167.18	-2.23**	0.028
Sex	-6200.54	5494.45	-1.13	0.262
Level of education	547.58	442.46	1.24	0.219
Farming experience	-471.75	432.72	-1.09	0.278
Constant	7009.80	15276.62	0.46	0.647
Diagnostic statistics				
R-square	0.7839			
F-value	37.88***			

Source: Field Survey, 2021
*** and ** implies statistical significance at 1% and 5% levels respectively

Constraints of Farmers Access to Credit

The constraints limiting farmers access to credit based on their perceived severity is presented in Table 4. The result revealed that absence of banks in the locality was ranked 1st as the most severe constraint faced by the farmers with the mean value of 3.74 in the study area. This was followed by lack of guarantor (3.22), distance from financial institution (3.15), lack of awareness (3.13), high administrative procedure (3.13), small size/inadequacy of credit (3.07) and demand for collateral (3.00) respectively. The result further revealed that the respondents also have other constraints that were perceived not to be severe in affecting their access to credit in the area. These include high interest rate, delay in disbursement, unwillingness to disburse loan, political interference and loan diversion among others. This result is similar to the findings of Agada (2017) for farmers in Federal Capital Territory, Abuja. The inference drawn from this finding is that the farmers are faced will several marauding constraints limiting their access to credit in the area. Apparently, this requires attention from the government and other relevant stakeholders for policy brainstorming and appropriation on how to alleviate limited access to credit among the farmers.

Table 5: Constraints of Farmers to Access Credit

Constraints	Weighted sum	Weighted mean	Remark	Rank
Absence of banks in locality	389	3.74	Severe	1st
Lack of guarantor	335	3.22	Severe	2nd
Distance from financial institute	328	3.15	Severe	3rd
Lack of awareness	326	3.13	Severe	4th
High administrative procedure	325	3.13	Severe	5th
Small size/inadequacy of credit	319	3.07	Severe	6th
Demand for collateral	312	3.00	Severe	7th
High interest rate	309	2.97	Not severe	8th
Delay in disbursement of loan	291	2.80	Not severe	9th
Unwillingness to disburse loan	284	2.73	Not severe	10th
Political interference	280	2.69	Not severe	11th
Loan diversion	280	2.69	Not severe	12th
Bureaucratic bottleneck	278	2.67	Not severe	13th
Gender	271	2.61	Not severe	14th

CONCLUSION AND RECOMMENDATIONS

The study concluded based on the results obtained that many of the farmers still don't have access to credit facilities in the study area. Annual income, interest rate farm size, member of cooperative and age were the determinants of farmers' access to credit. Constraints to credit access among the farmers in the area include absence of banks in the locality, lack of guarantor, distance from financial institutions, lack of awareness and high administrative procedure among others. The following recommendations were made:

1. Government in collaboration with relevant financial institutions should establish credit/loan offices close to farmers and should be operated by officials who would be familiar with farmers in the study area to increase awareness, reduce lending procedures and educate them on modalities of loan repayment.
2. Government should improve on extension service delivery to the farmers in the area so as to keep them abreast with information on financing opportunities as well as on improved farming practices.
3. Farmers should form and join cooperative societies to boost their chances of securing financial assistance for their farming and other livelihood activities.

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Comparative assessment of rationale and selection criteria for water yam (*Dioscorea alata*) production among yam farmers within the last five years in Ebonyi State, Nigeria.

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ABSTRACT

This study comparatively assessed the rationale and selection criteria for water yam production among water yam farmers in Ebonyi State. Multisatge sampling procedure was used. This involves the use of purposive and stratified sampling techniques at various stage. This was based on sampling frame contact from the ADP.This gives a total of 216 yam produces in the study area. The rationale or the determinant factor R^2 indicated 70.5%, 63.4%, 69.5%, 86.7% and 51.3% variability within the five production season and seven out of eleven variables showed positive coefficient and were significant at 1%, 5% and 10% respectively. Age, gender, educational level, farming experience, and farm size and production rate, market demand and maturity time are the determinant factors in selection criteria and major rationale in water yam production in the study area. Water yam farmers had higher variable sources of planting materials in 2017 (90.7%), 2020 (88.4%) and 2019 (79.6%) than other planting seasons, while moderate sources was recorded in 2018 (68.5%) and 2021 (50.3%). Rationale for selection also include multiple tuber ratio, high yield and high survival rate and together accounted for 93.5%, 93.1% and 87% in 2021, 2018 and 2019, while for resistant to pest and disease, drought tolerance and high yield as well as high market demand recorded for ten water yam accessions grown in 2017, 2018 and 2020 in comparison to others. Accessions of Okwalenwankata, Nvula and Mbula Obiaraohu scored above Likert scale mean and the rationale is good fit model in their production, hence recommended.

Key words: Comparative, assessment, rationale, selection criteria, production

INTRODUCTION

Water yam (*Dioscorea alata*) is one of the multi-species crop that belongs to the genus *Dioscorea* and family *Dioscoreaceae* (Tewodros and Getachew, 2013). Sesay (2013) noted that water yam (*D. alata*) originated in South East Asia, probably in Burma, and from there spread into the main land of East of Africa, *D.rotundata*, *D. cayenensis* and *D.dumetorum* complex originated from Africa, while aeriel yam (*D.bulbifera)* and Chinese yam (*D.esculenta)* originated from Asia, (Muluneh, 2006; Lebot, 2009, Norman *et al*., 2012). Of these species, *Dioscorea cayenensis*, *D. rotundata* and *D. alata* are the most cultivated and of greatest

economic interest in Africa (Norma *et al.*, 2012). In contrast to *D. cayenensis* and *D. rotundata*, that are native to Africa, *D. alata* comes from Asia (Gima *et al*., 2012).
They are now the most widely cultivated species both in Asia, America and have real economic significant in Africa (Norman *et al.*, 2012). These species are also threatened by genetic erosion due to many factors such as pest attacks and farming practices (Ngo Ngwe *et al.*, 2015).

Yam (*Dioscorea spp*) is an important food crop especially in the yam zone of West Africa and ranked the fourth most important world food crop (FAO, 2013). Its production generally has been challenged by many rationale considered to be crucial for effective production. This made yam production a task venture and production is still questionable (Verter and Bečvářová, 2014). Water yam production has been stagnated due to old and crude ideology considered to be fundamental by rural peasant farmers with option of no review on new sustainable production practices. Remarkable changes in water yam production has been ranked to be positive in increase production over the years, but the productivity and sustainable transformation of rural farmers stagnate in the face of skill shortages and some rationale (World bank and IMF, 2015).

Rationale in cultivation of some species are farming or production practices which the farmer considered being fundamental in cultivation of yams within his or her area. Improvement in yam production is dependent on the effectiveness of adoption of production rationale that increases accessions distinctiveness as an added value to the worth of yam (Gima *et al*., 2012). Some water yams are selected for cultivation either because they are highly tolerant to drought, somewhat resistant to pest and disease, has very good yield, early maturity, high multiple tuber ratio and tasteful resulting to real economic significance and this stems wide cultivation in West African countries including Nigeria where it is considered a staple food among southeastern farmers (FAOSTAT, 2011, Norma *et al*., 2012). In this, Nigeria is the largest producer of valued edible yams, accounting for 70% to 76% of total world production, with 35.07 million meteric tones and largest consumers of yams (Ezulke and Nwosu, 2006, World Bank and IMF, 2015). These exceptional qualities of water yam and adopted selection criteria by rural yam farmers encourage its production, reduces opportunistic erosion and guides against world food insecurity (FAO, 2011).

It is noted that the majority of poor smallholder yam farmers are still using traditional methods of farming and storage (Verter and Bečvářová, 2014). In addition, Kleih *et al.*, (2012) observed that all these methods are yam improvement for income and food security in West Africa. However, most of the selection criteria and rationale adopted by major producer of the world food security crop are considered to be crude, lack modern credibility which could outsmart weather vagaries and better livelihood of the farmers. It is on this fact that most of African countries incur huge lost and poor revenue generation accruable to yam production due to climate impact (Ishaku and Maharjan, 2014). The incessant alarm of global food insecurity and dearth of modern production facilities and technologies particularly in Ebonyi State arose the needs to investigate the selection criteria and practices used by water yam farmers in production of yam in the study area. The broad objective of this study is to compare rationale and selection criteria for water yam production within the last 5 planting seasons in Ebonyi State. Specific objectives include (i) identifying the socio-economic characteristics of water yam producers of the study area (ii) comparing the major actors in adoption of selection criteria and choice of rationale and (iii) identifying marketing demand as one of the selection criteria.

METHODOLOGY

Ebonyi State is one of the South Eastern States found in one of the six geopolitical zones in Nigeria. The area lies between longitude $7°30^1$ and $8°30^1$ east and latitude $5°40^1$ and $6^0\ 54^1$ north of equator in the Southeastern part of Southern Nigeria. the population has be approximated to two million,eighty hundred and eighty thousand and four hundred people occupying an area of land totaling 6,488km^2 (NPC and National Bureau of Statistic, 2016). Multisatge sampling procedure was used. This involves the use of purposive and stratified sampling techniques at various stage. This was based on sampling frame contact from the ADP. In the first stage, 3 LGAs each were purposively selected from the 3 senatorial zones based on massive yam production in the area. In the second stage, 2 autonomous communities were selected from each of the 3 LGAs, to give a total of 18 communities. The third stage involved selection of 54 villages with a total of 216 yam produces in the study area. In all, a total of 216 stratified and randomly selected respondents participated in the study. Data were collected using interview schedule to obtain relevant information from respondents and by using questionnaires structured in line with the specific objectives. These were administered in form of oral interview schedule in order to ensure that responses to the questions were correctly filled. Data collected were analyzed using a statistical tools frequency and percentage distribution. Tobit regression was used to establish the socio-economic adoption of the rationale for water yam production, while factor analysis was used to identify factors affecting yam production. The implicit forms of the Tobit regression used to establish the influence of farmers socio- economic factors were represented by age (X_1), gender (X_2), education (X_3), farming experience (X_4), source of farmer income (X_5),source of planting material (X_6), farm size(X_7),production rating (increase, decrease) (X_8), market demand (X_9), maturity rating (late, medium & early) (X_{10}) and access to credit facilities (X_{11}). Level of rationale and selection criteria adoption is represented with (Y) and estimated using the function as:

Y= $f(X_1+ X_2 + X_3 + X_4 \ldots\ldots\ldots\ldots\ldots\ldots X_{11}$ + error term) implicit function. Descriptive statistics such as frequency counts and percentages were used to analyze and compare major actors in adoption of rationale and choice of selection criteria, while 5 points Likert scale = $\frac{5+4+3+2+1}{5}$ = 3 market demand– 1-very poor, 2-poor, 3-fair, 4- good, 5 – very good was used to assess market demand.

RESULT AND DISCUSSION

Effect of socio- economic factors on respondents' choice of rationale and selection criteria on water yam production.

The result in table 1 showed the Tobit regression rationale adopted by farmers in water yam production in the study area. The chi-square values were all significant at 5% level of probability for the five years indicating goodness of fit of the model used. The rationale or the determinant factor R^2 values 0.705, 0.634, 0.695, 0.867, and 0.513 respectively, indicated 70.5%, 63.4%, 69.5%, 86.7% and 51.3% variability in adoption of rationale and selection criteria were explained by independent variables.

The coefficient of age was statistically significant and negative at 1% level probability in the three planting seasons of 2017, 2018 and 2017 respectively. This implied that as the farmer grows older, decrease in choice of rationale is adopted or less concerned on the rationale used in water yam production. This is true as the farmer might not be able to attend seminars or use internet for new information on techniques in water yam production. This leads to shortage of skills and innovation whereby the farmer is stagnated with old skill or experience. However, the coefficient of age in 2016 was statistically significant and positive at 1% level of probability. This implied that the older the farmer the higher the rationale and selection criteria adoption and consequently the output. This is in conformity with apriori expectations and in tandem with World Bank and IMF (2015) reports that the productivity and sustainable transformation of rural farmers stagnate in the face of skill shortages and some rationale.

Furthermore, the coefficients of gender, educational level, farming experience, and farm size and production rate obtained were statistically significant and positive at 5% level of probability, while the coefficients of market demand and maturity time obtained were statistically significant and positive at 10% level of probability. This implied that the earlier the maturity of water yam, the earlier the utilization which increases market demand. However, the higher the number of age male and female farmers, educational attainment and farm size in water yam cultivation the higher the increased production (output). The implication is that there is no gender restriction in growing water yam in the study area and the higher level of education attained with more years in farming experience, the higher the adoption of the rationale and the higher the production (output) which was rated to have increased from 2017 to 2021. This is in conformity with apriori expectations and in tandem with Okoye *et a l*.,(2009) as well as Ada *et al.*, (2007) who revealed that the greater the years of farming experience, the greater the farmers' ability to manage generally specific factors that affect the farm business. The result also collaborated with findings of Omojola (2012) as well as Eyitayo *et al*. (2010) who reported positive effects of higher educational level, farm size and amount of credit obtained by seed yam farmers on output.

Major actors in adoption of rationale and selection criteria for water yam production.
The result in table II revealed major actors in adoption of rationale and selection criteria used in water yam production in the last five in the study area. The result indicated that water yam farmers had higher variable sources of planting materials in 2017 (90.7%), 2019 (88.4%) and 2020 (79.6%) than other planting seasons. However, water yam production witnessed moderate sources of planting materials in 2018 (68.5%) and 2021 (50.3%) respectively. The higher the sources of planting material the lower the cost and the lower the sources the higher the cost. High cost of planting materials increases high cost of production thereby reduce net farm income. There was remarkable increase in water yam production in the study area over the years. However, increase to decrease production of 2021 and 2018 in comparison to other years was attributed to climate and weather impact resulting to flood, high cost of maintenance, and pest and disease attack. This is synonymous with the findings of Ishaku and Maharjan (2014) who noted that most of African countries incur huge lost and poor revenue generation accruable to yam production due to climate impact.

Market demand of water yam had been from very poor to very good demand, the highest demand was recorded in 2021 (60.2%) than other production seasons. This could be as a result of decline in yield attributed to climate and weather vagaries and intense global food demand in recent years. Furthmore, very poor market demand might also arise due bad qualities of water yam listed to include late maturity time, high vegetative growth, soil selectivity, multiple small tubers and non-utilization in social functions. In contrast, good qualities of growing water yam were enumerated to include multiple tuber ratio, high yield and high survival rate and together accounted 93.5%, 93.1% and 87% in 2021, 2018 and 2020 production years respectively. Water yam farmers' engage in production of those accessions of water yam that are resistant to pest and disease, drought tolerant and can yield high as well as high market demand. These was observed in water yam grown in 2017, 2018 and 2020 in comparison to others grown in 2019 and 2021. These are considered as the major determinant of production effectiveness in water yam production enterprise. This is in conformity with apriori expectations and in tandem with Kleih *et al*., (2012) who observed that all these methods are yam improvement for income and food security in West, Africa.

Table III. Marketing demand was rated by farmers using 5 points Likert scale from very poor to very good demand. The highest demand was recorded in in accessions of water yam called Okwalenwankata, Nwawafu or Akoawafu (5.8) across the three senatorial zones and performed above Likert scale mean (3.0), this was followed by other accessions called Nvula or Mbala or Mbula and Mbula Obiaraohu at mean value of 5.5 and 5.1 and at acceptable decision rules of good and very good respectively. The only rejected decision was recorded in water yam accession Akpuruakputu having scored below Likert mean value (2.3). Marketing demand is an additional qualities of water yam production having grown for high multiplication tuber ratio. This observation corroborated with the findings of FAO (2011) who reported that exceptional qualities of water yam and adopted selection criteria by rural yam farmers encourage its production, reduces opportunistic erosion and guides against world food insecurity.

Table I: Tobit regression assessment of rationale and selection criteria for water yam production in the last five years

Variable	2017	2018	2019	2020	2021	Pooled
Constant	3.159 (-4.56) ***	- 1.035 (-0.11)	-1.381 (-0.87)	4.473 (1.26)	1.942 (1.51) *	0.839 (-1.48) *
Age (years)	-0.98 (-1.66) ***	0.778 (-2.31) ***	0.082 (0.36)	-0.059 (2.09) ***	-0.326 (-3.02) ***	-0.347 (-1.16) ***
Gender (sex)	0.847 (3.36) ***	-0.029 (-0.11)	0.055 (0.09)	0.671 (6.28) ***	0.483 (3.13) **	0.198 (2.11) **
Education status	-0.412 (-0.68)	-0.096 (-0.41)	0.739 (3.01) **	0.076 (-0.38)	0.709 (1.56) **	0.292 (0.22) **
Farming experience	0.058 (2.17) ***	0.046 (3.26) ***	0.107 (1.46) **	0.055 (0.2.54) **	0.159 (2.33) **	0.019 (2.29) **
Source of income	0.437 (1.21) *	0.277 (0.35)	0.209 (0.75)	0.416 (1.12) *	0.116 (0.58)	0.233 (0.87) *
Source of planting material	0.937 (1.46) **	0.601 (0.42)	0.067 (1.11) **	0.895 (2.34) **	0.245 (0.37)	0.819 (0.77) **
Farm size (Ha)	0.079 (0.35)	0.141 (2.51) **	0.313 (1.13) **	0.135 (0.55)	0.167 (1.02) **	0.165 (0.68) **
Production rate	1.152 (2.86) **	0.582 (1.44) **	0.678 (1.09) **	0.935 (2.32) **	0.215 (0.41)	0.422 (1.77) **
Market demand	0.172 (0.46)	0.199 (0.81)	0.082 (0.13)	0.257 (1.01) *	0.621 (1.43) **	0.148 (1.08) *
Maturity time	2.165 (1.04) *	0.183 (1.52) *	0.125 (0.38)	0.226 (0.89) *	0.144 (0.49)	0.214 (1.06) *
Access to credit facilities	-0.573 (-1.22)	0.336 (-0.86)	0.235 (0.63)	-0.626 (-1.38)	-1.217 (-1.10)	-0.096 (0.31)
Chi-square	26.11**	13.87**	20.14**	29.03**	12.13**	17.20**
R^2	0.705	0.634	0.695	0.867	0.513	0.658

Log likelihood	28.988	12.899	19.233	-32.670	11.436	21.416

Source: Field survey 2017/2021. *, ** and *** indicate significant at 10%, 5% and 1% respectively.

Table II: Distribution of major actors in adoption of rationale as it affected water yam production in the last five years

Years	2017		2018		2019		2020		2021	
Actors	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Source of planting material	196	90.7	148	68.5	191	88.4	172	79.6	109	50.5
Production level	185	85.6	157	72.7	167	77.3	192	88.9	116	53.7
Market demand	105	46.6	97	45.9	100	48.0	98	42.0	130	60.2
Good quality that make for production	119	55.1	201	93.1	115	53.2	188	87.0	202	93.5
Bad quality that make for production	96	44.4	112	51.9	116	53.7	101	46.8	159	73.6
Drought tolerance	145	67.1	203	93.9	199	92.1	174	80.6	87	40.3
Pest and disease resistance	168	77.8	176	81.5	135	62.5	148	68.5	102	47.2
Yield condition	182	84.3	169	78.2	117	54.2	133	61.6	99	43.6

Source: Field survey 2017/2021. Multiple responses***, freq. frequency and % - percentage

Table III: Farmers' rating of market demand of water yam using 5 points Likert scale

No	**Accession local name best ten selected**	**Farmers rating**	**Mean score**	**Decision rule**
1	Nvula/mbala/mbula	Good	5.5	Accepted
2	Okwalenwankata and Nwawafu	Very good	5.8	Accepted
3	Akpuruakputu	Very good	2.3	Rejected
4	Ajingworo	Fair	3.1	Accepted
5	Egboro-Mbala	Good	5.0	Accepted
6	Igborogidi	Fair	4.4	Accepted
7	Mbula Obiaraohu	Very good	5.1	Accepted
8	Nneonwuka	Good	4.2	Accepted
9	Mbula America	Good	4.2	Accepted
10	Uranium	Good	4.0	Accepted

5 points Likert scale = $\underline{5+4+3+2+1}$ = 3 market demand– 1-very poor, 2-poor, 3-fair, 4- good, 5 – very good

CONCLUSION AND RECOMMENDATIONS

The result indicated that age, gender, educational level, farming experience, and farm size and production rate, market demand and maturity time are the determinant factors been significantly at 1%,5% and 10% in selection criteria and major rationale in water yam production in the study area. Selection of water yam accession without consideration to above factor could amount to low or poor production of water yam in the study area. Having accessions that performed above Likert scale mean with intrinsic qualities for selection criteria, including multiple tuber ratio, high yield and high survival rate, resistant to pest and diseases, drought tolerance and high market demand for some accessions is an indication that these traditional practices of choice of planting material are still good when there is no alternative. However, the rationale and selection criteria goodness fit is challenged by climate and weather impact resulting to flood, high cost of maintenance, and pest and disease attack. The rationale goodness fit is appreciated in some accessions performance and the following recommendation are proffered.

It is recommended that traditional rationale and selection criteria observed and enumerated are good fit model for growing water yam particularly in Ebonyi State, and farmers should be assisted in documentation of the rationale since there is no alternative. There should be a gene bank for improved genotype of water yam which farmers can be assisted with for excellent production to reduce incessant sourcing of planting materials. Water yam producers in the study area can be assisted with extension agents to equip them of adoption of good rationale and selection criteria for higher production (output).

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Analysis of perceived constraint on adoption of traditional conservation methods and storage media by yam farmers in Ebonyi State, Nigeria

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ABSTRACT

This study was to analysis perceived constraints on adoption of traditional conservation methods and storage.
Multistage sampling procedure was used. This involves the use of purposive and stratified sampling technique at the various stages. This was based on sampling frame contact farmers from ADP. This gives a total of 216 yam farmers who participated in the study. The result of multiple regression on the effect of socio-economic characteristic of the farmers had a coefficient determination (R^2) of 73.3% and seven variables out of nine had a positive coefficient and were significant at 1%, 5% and 10%. Farming experience, storage sites, conservation methods, education attainment has positive significant relationship with the adoption and storage site for yams as well as source of farmer's income and farm size. Adoption of conservation strategies utilizable by farmers in the study area include keeping in multiple plots (40.7%), by giving others to plant (33.3%), clean planting materials (26%) and alternatively sold to outsides (37%), sold to one person in the community (36.1%) and gifted to outsiders (26%) and three storage sites identified include storage in the barn (49.1%), storage in the field (37.0%) and garden (13.9%) with mostly species of *Dioscorea alata*, *D. rotundata*, *D.cayenensis*, *D.dumentorum* and *D. bulbifera*. Adoption was constrained by lack of capital, high cost of fertilizer, high cost of herbicide, poor road network, open grazing, lack of grant and subsidy, lack of modern storage facilities and land degradation issue, usage of traditional conservation method and poor innovation. Policy recommendations were proffered.

Key words: Investigation, perceived constraints, adoption, conservation methods, storage media

INTRODUCTION

Yam (*Dioscorea spp*) is an important food crop especially in the yam zone of West Africa and ranked the fourth most important world food crop (FAO, 2013). It is a multi-species crop that belongs to the genus *Dioscorea* and family *Dioscoreaceae* (Tewodros and Getachew, 2013). It

is today cultivated in almost all the continents of the world as yam is found in Africa, India, Southeast Asia, north/southern America and Australia with about 600 described species (Tewodros and Getachew, 2013). West Africa accounts for 90-95% of world yam production with Nigeria the largest single producer. In 2004, global yam production was about 47 million metric tons (MT) with 96% of this coming from Africa. IITA (2010) reported that yams are now farmed/cultivated on about 5 million hectares in about 47 countries in tropical and sub-tropical regions of the world. Yams are the fifth most harvested crops in Nigeria, following cassava, maize, guinea corn, and beans/cowpeas. More so, cassava, yams are the most commonly harvested tuber crops in the country (National Bureau of Statistics, 2012).
Yam being the most common food of African continent is posit with challenges of conservation, preservation both in filed and at home barn or garden. This has made yam farmers in sub-Saharan Africa to source for preservation methods that will keep harvested yam off spoilage at a considerable time pending for marketing and the ones that will be used as planting materials. FAO (2013) reported that on the volume of yam lost in metric tons in Nigeria, Ghana and Côte D'Ivoire between 1961 and 2009; Nigeria lost an annual average of 10% within the period under study. The country recorded the highest yam lost in 2006 with over 3.7 million metric tons. Inadequate preservation, storage and processing facilities, marketing and market access to yam products are attributed to yam waste or lost in the country. There are many indigenous storage structures and methods commonly find in West Africa.

It is noted that the majority of poor smallholder yam farmers are still using traditional methods of farming and storage (Verter and Bečvářová, 2014). Ayanwuyi *et al.*,(2011) revealed that the adoption and no option on the modern conservation methods are the perceived constraint on yam production in some States of Southwestern Nigeria. Similarly, Kleih *et al*., (2012) observed that all these methods are yam improvement for income and food security in West, Africa. The crops stored is associated with these indigenous storage systems, have antecedent problems of postharvest losses including: decay, drying off, rotting; respiration and temperature; sprouting while in storage; and pests like insects, nematodes, rodents and animals. This made yam production a task venture and production is still questionable (Verter and Bečvářová, 2014). It is noted that the majority of poor smallholder yam farmers are still using traditional methods of farming and storage (Verter and Bečvářová, 2014). This conservation and storage structures have made agriculture in rural areas of West Africa countries to remain at subsistence level. Osunde and Orherha, (2009) noted that conservation methods are posit with challenges of sprouting, quick germination, rotting, weight and decay recorded to significant losses at about 12% for a method that doesn't allows six hours air flow. However, due to wide experience of yam farmers, these methods have sustained yam production in Nigeria to a certain level. Okoye *et al*.,(2009) revealed that the more experienced the farmer is, the more efficient in managing factors that affect farming business, including decision making process and associated risks in both adoption and rejection of any innovation in farming business. Similarly, Ada *et al*., (2007) also revealed that the greater the years of farming experience, the greater the farmers' ability to manage generally specific factors that affect the farm business. The major task therefore was to find a suitable and effective storage media, method or technology to keep the excess harvest and to make the crop available all the year round.

METHODOLOGY

Ebonyi State is one of the South Eastern States found in one of the six geopolitical zones in Nigeria. The area lies between longitude $7°30^1$ and $8°30^1$ east and latitude $5°40^1$ and $6^0 54^1$ north of equator in the Southeastern part of Southern Nigeria. the population has be approximated to two million,eighty hundred and eighty thousand and four hundred people occupying an area of land totaling 6,488km^2 (NPC and National Bureau of Statistic, 2016).The climate is tropical with vegetation typical of guinea savannah in the rainforest zone of West Africa. Farming is a major occupation of the people with key arable crops comprising of maize, yam, cassava, cocoyam and rice. Rapid rural appraisal (RRA) involving multistage purposive and stratified sampling technique was adopted for farmers' selection based on sampling frame of contact farmers of the Agricultural Development Programme (ADP) in Ebonyi State, to select a total of 216 yam producers in the study area. In the first stage, 3 LGAs each were purposively selected from the 3 senatorial zones based on massive yam production in the area. In the second stage, 2 autonomous communities were selected from each of the 3 LGAs, to give a total of 18 communities. The third stage involved cluster sampling of the yam farmers. From each community, 3 stratified villages were selected and 4 farmers stratified according to gender per village was randomly involved. In all, a total of 216 stratified and randomly selected respondents participated in the study. Data were collected using interview schedule to obtain relevant information from respondents and by using questionnaires structured in line with the specific objectives. These were administered in form of oral interview schedule in order to ensure that responses to the questions were correctly filled. Data collected were analyzed using a statistical tools of means, frequency distribution and percentage. Multiple regression was used to establish the socio-economic determinants of yam production, while factor analysis was used to identify factors affecting yam production. The implicit and explicit forms of the multiple regression used to establish the influence of farmers socio- economic factors were represented by gender (X_1), age (X_2), marital status, (X_3), storage sites (X_4), conservation methods (X_5), farming experience (X_6), educational status (X_7), source of income (X_8) and farm size (X_9). Level of traditional conservation methods adoption and storage media is represented with (Y) and estimated using the function as:

$Y= X_1+ X_2 + X_3 + X_4$………………..X_9 implicit function.

$Y= a_0 + a_1x_1 +a2_+ x_2 + a_3x_3 + a_3x_4$………………..$a_2x_9$ +ET. Explicit function. Descriptive statistics was used to analyze perceived constraints and adoption determinant, while multiple regression analysis was used to analyze objective (i) and objective (iv) was analyzed using factor analysis.

RESULT AND DISCUSSION

The distribution of the respondents according to their socio-economic characteristics is shown in Table 1. From the table, most of the respondents (91.7%) were male famers who fall within the age bracket of 50-60 years and above. Again, 89.4% were old and middle aged men and women above the age of 50.The implication is that yam cultivation is undertaken by old and middle aged people with low energy to withstand the drudgery of yam production. These farmers preserve their farm produce in the barn/home or field by keeping the in the multiple plots or given other to plant so as to collect and plant in the next season. These farmers have engaged in this methods for long having been long with wide farming experience ranged from 20 to 50 years. On level of educational attainment, majority (59.7%) of yam farmers attained one form of formal education or the other ranging from primary to tertiary education. This farmers solely depend on farming as their only source of income and who cultivate from 1 to 10ha of land annually. This result corroborated with the findings of Okoye *et al*., (2009) who revealed that the more experienced the farmer is, the more efficient in managing factors that affect farming business, including decision making process and associated risks in both adoption and rejection of any innovation in farming business. the result is also synonymous with findings of Ada *et al*., (2007) who reported that the greater the years of farming experience, the greater the farmers' ability to manage generally specific factors that affect the farm business. The farming left in the hand old yam farm who relied on crude preservation method makes yam production questionable. This observation is in consanace with findings of Verter and Bečvářová, (2014) who noted that yam production is questionable in Togo.

Farmers' socio-economic factors on yam conservation adoption methods and storage sites

The multiple regression analysis was used to predict the effect of farmers' socio-economic factors on yam conservation adoption methods and storage sites. A multiple regression model employed indicated that coefficient of determination (R^2) was 73.3%. This implied that the variation in the dependent variable (Y) was influenced by the combined effects of independent variable (X_1-X_9), while the remaining 27.7% of the dependent variable (Y) was due to some other important variables that were not included. The R^2 justified the goodness of fit of the regression model, and this indicates the explanatory variable exerts effects on the explained variable. The result also indicates that age had negative relationship with adoption of conservation methods and choice of storage sites. This implied that as the farmers grow older, less choice of conservation methods are adopted than when they are younger. The farmers might store yam at filed as they have no other modern alternative methods of storage after barn in the farmstead or farmers' resident. An increase in age of farmers is an increase in farming experience which have positive significant relationship. This implies that the more years the farmer engage in yam production the more stable in conservation methods and maintaining a suitable site for storage. This result corroborated with the findings of Okoye *et al*., (2009) who revealed that the more experienced the farmer is, the more efficient in managing factors that affect farming business, including decision making process and associated risks in both adoption and rejection of any innovation in farming business.

Education attainment has positive significant relationship with the adoption and storage site for yams. This implies that the more educated the farmer is the more conversant in adoption of the methods. A unit increase in the level of education leads to 0.567 (56.7%) increased in yam conservation methods of adoptions and storage sites. The source of income had a positive significant effect at 10% level of probability. This was associated with the fact that the more source of income the more land to acquire in cultivation of yam as well the more preservative methods to adopt. Storage site indicated negative significant effect on adoption of conservation. Increase in storage site might be associated with increase in the factors that could cause wastage or loss yam tubers, while positive relationship in the farm size indicates that the more the farm size the more yam and the more methods to adopt to save the yam for next planting season. Conservation methods adoption and storage sites were positively sign and this method are safe methods to preserve yam for future use. This result corroborated with findings of Kleih *et al*., (2012) who observed that all these methods are yam improvement for income and food security in West, Africa.

Perceived farmers attitude and activities of major actors in adoption of conservation methods and storage sites of yam

The result shown in Table 2 indicates that most of the yam farmers (40.7%0 adopted keeping in multiple plots as alternative methods of preservation. This was closely followed by giving others to plant (33.3%). This implied that the most cultivated yam species (*Dioscorea rotundata,;D. alata* and *D. cayenensis*) were preserved mostly by these methods. All the yam species are either stored in the barn or field with few storage made at the garden and can also be sourced number of measures including sold to outsides (37%), sold to one person in the community (36.1%) and gifted to outsiders (26%). These stored yams are perceived to be affected by loss in the weight, pest, low durability and storage media. The adoption of conservation strategies helps to reduce losses incurred in yam storage sites and methods. This result is synonymous to findings of FAO (2013) that on the volume of yam lost in metric tons in Nigeria, Ghana and Côte D'Ivoire between 1961 and 2009; Nigeria lost an annual average of 10% within the period under study. Similar result was observed by Osunde and Orherha (2009) who noted that conservation methods are posit with challenges of sprouting, quick germination, rotting, weight and decay recorded to significant losses at about 12% for a method that doesn't allows six hours air flow.

Factors that necessitated constraints to yam conservation and adoption methods and storage site

Many factors are put forward as major constraints in adoption of yam conservation methods. The constraints are grouped into three factors depending on the factors that loaded high in each case. Factor one was named government policy issue because of the variables that loaded high are related to government policies. These include unfavorable government policies, poor road network, open grazing, lack of grant and subsidy, lack of modern storage facilities and land degradation issues. These factors are rated in descending other .755, .603.569, .544, .509 and .305. Factor two was named institutional management problem, they include the usage of traditional conservation method, poor innovation, low durability, and lack of access to extension service, use of fertilizer, poor road network, flood problem and land degradation, and lack of modern storage facilities. Factor three was named management and market information which loaded high on lack of capital, high cost of fertilizer, high cost of herbicide, and usage of traditional conservation method, poor innovation and low durability. These and many other factors contributed to constraints in adoption of traditional conservation methods and storage site. This is in agreement with the findings Ayanwuyi *et al.*, (2011) who revealed that the adoption and no option on the modern conservation methods are the perceived constraint on yam production in some states of Southwestern States of Nigeria.

Table 1. Social economic characteristics of adoption conservation methods on yam production in Ebonyi State

Variables	Frequency	Percentage (%)
Male	198	91.7
Female	18	8.3
Age (years)	**216**	**100**
<30	7	3.2
31-40	16	7.4
41-50	50	23.2
51-60	55	25.5
>60	88	40.7
Storage site		
Field	51	23.6
Garden	14	6.5
Barn/home	99	45.8
Traditional conservation methods		
Keeping in multiple plots	88	40.7
Giving others to plant	72	33.3
Use clean planting materials	56	26.0
Farming experience		
<5	5	2.3
5 – 19	64	29.6
20 – 30	64	29.6
30 – 50	83	38.4
Educational qualification		
None	87	40.3

Primary	42	19.4
Secondary	43	19.9
Tertiary	44	20.4
Source of income		
Farming	139	64.4
Business	7	3.2
Formal employment	2	0.9
Informal employment	4	1.6
Formal emp. & farming	18	8.3
F. &business:	46	21.3
Farm size		
< 0.50	4	1.9
1	24	11.1
1 – 2½	115	53.2
5 – 10	73	33.8

Source: Field survey 2021.

Table II. Effects of farmers' socio-economic factors on yam adoption of conservation methods and storage sites

Variable symbol	Variable name	Regres. coefficient	Standard error	T- value	P-value
Y	Constant	4313.867	9231.253	89.211	0.000***
X_1	Gender	-3430.316	641.129	2.385	0.316 ^{NS}
X_2	Age	-120.565	291.135	-1.351	-0.003* *
X_3	Marital status	467.123	213.124	1.298	0.145 ^{NS}
X_4	Storage sites	-40.615	98.431	-3.562	0.004* *
X_5	Conservation methods	112.525	29.324	2.536	0.014**
X_6	Farming experience	48.146	189.032	2.175	0.000***
X_7	Educational status	202.667	217.062	3.103	0.003* *
X_8	Source of income	9.443	239.112	1.872	0.082*
X_9	Farm size	0.418	312.056	2.113	0.014* *

Source: Field survey 2021. *, ** and *** indicate significant at 10%, 5% and 1% respectively. NS= not statistically significant. Durbin Watson stat. constant (Dwb=1.931), (R^2 = 69.7%), Adjusted R^2 = 66.7% and F- stat. 1.512

Table III. Perceived farmers' attitude and major actors in yam conservation methods

Variables	Frequency	Percentage (%)
Conservation methods		
Keeping in multiple plots	88	40.7
Giving others to plant	72	33.3
Use clean planting materials	56	26.0
Storage site		
Garden	30	13.9
Field	80	37.0
Barn/home	106	49.1

Alternative conservation methods		
Gift to outsiders	88	40.7
Sold to outsiders	78	36.1
Sold to one person in the community	50	23.1
Species choice		
Dioscorea alata	63	29.2
Dioscorea rotundata	68	31.5
Dioscorea cayenesis	40	18.5
Dioscorea dumentorum	30	13.9
Dioscorea bulbifera	15	6.9

Source: Field survey 2021.

Table IV. Constraints associated with adoption of yam conservation methods and storage sites in Ebonyi state

Variable code	Variable name	Factor 1 Government policies	Factor 2 Institutional	Factor Management/ marketing information
1	Lack of modern storage facilities	.509	.452	.102
2	Poor innovation	-.334	-.611	.344
3	Storage sites	.095	.457	.342
4	Usage of traditional conservation method	-.182	.634	-.422
5	Low durability	-.341	.564	.323
6	Lack of capital	.089	-.398	.607
7	Lack of access to extension service	.167	.545	.079
8	Lack of grant/subsidy	.544	.116	.324
9	Unfavourable government policy	.755	.324	.221
10	Flood problem and land degradation	.305	.484	-.259
11	Poor road network	.603	.499	.218
12	Open grazing issues	.569	.411	-.200
13	Use of fertilizer	.078	.542	.321
14	High cost of herbicide	-.433	.388	.497
15	High cost of fertilizer	.356	-0.87	.577

Source: Field survey, 2021

CONCLUSION AND RECOMMENDATION

The adoption of conservation methods is dependent on age and education attainment of the yam farmers as the younger farmer have more curiosity to adopt multiple conservation methods than older farmers who considered it stressful. It is concluded that all the yam species are either stored in the barn or field with few storage made at the garden or alternatively keeping in multiple plots amounting to (40.7%) or by giving others to plant (33.3%) and use clean planting materials (26%). It is by extension sold to outsides (37%), sold to one person in the community

(36.1%) and gifted to outsiders (26%) who can be accessible in case of failed production as a result of multiple factors surrounding yam production. Adoption of has been constrained by lack of capital, high cost of fertilizer, high cost of herbicide, poor road network, open grazing, lack of grant and subsidy, lack of modern storage facilities and land degradation issue, usage of traditional conservation method and poor innovation. Adoption and good practices of these methods also have sustained yam production over the years. However, bulk of good policies that would ensure reduction in open grazing, giving of farmers grants and incentives inform of grant, subsidy, fertilizers and improved yam setts or yam seed with modern preservation and storage facilities are recommended.

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Socio-economic Characteristics of Women Empowered Through Fish Farming and Value Addition in Cross River State, Nigeria.

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ABSTRACT

The study examined the socio-economic characteristics of rural women empowered through fish farming and value addition in Cross River Central District of Cross River State, Nigeria. A total of one hundred and twenty five (125) women were selected and empowered through training on fish farming and value addition from five Local Government Areas of the state. The objectives of the empowerment training program was to develop enterprising women in fish production and value addition in processing, packaging and marketing for increased income generation and improve living standard. Structured questionnaire was used to obtain necessary data required. Data was analysed with descriptive statistics such as frequency, mean and percentages. The result revealed the majority (53.6%) of the respondents were youths, who were married (68%) and had secondary education (65.6%) with little value addition experience (66%) and belonged to cooperative society (70%) in the study area. It is recommended therefore that, with the potential and zeal of the women towards the empowerment training program, more other government intervention on food production value addition and value chain will go a long way in enhancing capacity building, increase food security, income and raising their living standard in the study area.

Keywords: Socio-economic characteristics, women, fish farming, value addition.

INTRODUCTION

Fisheries play a major role in the nutritional security and in food production for people around the world. Fish is known for its high nutrition as it has various essential micronutrients, mineral and fatty acids. Fish is an important part of the diet of many communities and large numbers of families earn a living from fish farming/fishing, fish processing and marketing. The nation's fast growing population of about 170million and its very high demand of fish, of 2.66 million metric tonnes, has positioned fish production on a much stronger market-driven patty based on commercial production in peri-urban areas (Onunka, 2022). Tilapia (*Orechromia spp*) and catfish (*Clarias spp)* are the major aquaculture products in Nigeria and these are produce and marketed under different systems along value chains and value addition. In order to improve revenue generated and for the products present reasonable opportunity for additional revenue generation, job creation and effective post-harvest management, value addition concept is required. This helps fish business, fish farmer and middlemen (fish mongers) simply add value to the fish via fish processing (fish smoking etc). This act has created more varieties and forms of fish products which are widely acceptable in the fish market. Not only does value addition give the products high economic value which is consequently brings higher income to the fish managers but also address market competition, post-harvest losses and food security (Karthickumar, Hozen, Karthickumar and Balasundari, 2020). Women are known for their multi-talent tackling both the indoor and outdoor activities without much effort. In the local markets of the coastal regions in Nigeria like the Cross River State, women are tending to be vendors to sell the catch of that day. Most times, the women are forced to sell fresh fish at a lower cost which results low income and living standard, as the fresh fish does not have a long shelf life. In order to prevent these issues and to improve the living condition of the Cross River Central District women, there arose the need for empowerment training on fish farming and value addition in the study area. Hence, the objectives of the empowerment training program were to disseminate information on fish farming (Pisciculture) and to develop value addition enterprising women, who would acquire skills in processing, packaging, and marketing to prevent post-harvest losses, increased food security and improved living standard in the study area.

METHODOLOGY

The study was conducted in the Cross River Central District of Cross River. It examined rural women who were empowered through training program on fish farming and value addition (processing, packaging and marketing) technologies in Ikom area of the States. Twenty-five (25) women were selected from Six (6) Local Government Area of the district which includes: Abi, Yakuri, Obubra, Ikom, Etung and Boki. A total sample size of one hundred and fifty (150) respondents trained and empowered. Structured questionnaire was used to illicit information on the socio-economic characteristics of the respondents. Data collected were analysed with descriptive statistics such as frequency, percentage, table and mean. The objectives of empowerment training program were to disseminate fish farming technologies and develop enterprising women in fishing and value addition who were to acquire skills in processing, packaging and knowledge in fish marketing for increased income generation and improve living standard in the study area.

RESULTS AND DISCUSSION

Table 1 represents the socio-economic characteristics of the respondents. The results showed that the mean of age of the respondents were 33 years. This indicates that the respondents were within the active productive age and great potential to develop enterprise in fishing and value addition. This also implies that the respondents were youth who would address market competition which agree with report of Onunka, Chima and Mbanaso (2016). The result revealed that majority (68%) of the respondents were married and living with their husbands and children. This indicates high level of responsibility. The result showed that most (65.6%) of the respondents had secondary education which implied moderate education level. Mauracher and Ragszzoni, (2005) opined that education obviously influences people's basis for acceptance and acquired processing enterprise in fish production and management of natural resources. The result further revealed that majority (66%) of the respondents had no experience in fish farming and value addition while 4% had experience in such enterprise. Effiong (2005) indicated that freshers in business are prone to efficient utilization of available resources than the experienced ones. Also, the result of the finding showed that majority (70%) of the respondents belonged to cooperative society which indicated great potential in socialization and interaction thereby bringing customers to purchase the processed fish for increased income generation in the study area.

Table1:Distribution of Respondents According to Socio-economic Characteristics n=150

Variables	Freq	Percentages	Mean
Age (yrs)			
21-30	9	6.4	
31-40	68	53.6	33
41-50	36	28	
51-60	11	8	
60 and above	6	4	
Marital Status			
Married	87	68	
Single	16	12	
Divorced	7	4	
Separated	20	16	
Educational Status			
Primary	35	28	
Secondary	82	65.6	
Tertiary	13	6.4	
Experience			
No	95	66	
Yes	45	34	
Cooperative Society			
Yes	100	70	
No	50	30	

Source: Field Survey, 2022.

CONCLUSION

The result of the finding revealed that the mean average of the respondents were 33 while 68% were married and had secondary education as their highest level of education. The result also showed that majority (66%) of the respondents had no experience in fishing and value addition while 70% belonged to cooperative society in the study area. It is therefore recommended that, with the potential and zeal of the respondents towards the empowerment training programme, more of other government intervention on food production, value addition and value chain will go a long way in enhancing capacity building, increased food security and income in the study area.

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Effects Of Hiv/Aids Among Men, Women And Youth In Crop Production Of Jema'a And Giwa Local Government Areas Of Kaduna State, Nigeria

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ABSTRACT

This study was conducted, to analyze the effects of HIV/AIDS among men, women and youth in crop production in Jema'a and Giwa local government areas of Kaduna state, Nigeria. Jema'a and Giwa were purposively selected due to the prevalence of HIV/AIDS and the youth and women are predominantly crop farmers. A sample size of 192 respondents was randomly and proportionately selected for the study. Structured questionnaire was used to elicit relevant data from the respondents. Percentages and analysis of variance (ANOVA) were used to analyze the data. The results showed that women were 41.8% and youth58.2%, and 73.0% had secondary education status, about 70% of the respondents earned between ₦1, 000.00 - ₦15, 000.00 monthly with the mean earning of ₦12, 595.1. About 51 of respondents used family labour while 46% had family size of 6-10 members, about 69% were married and 40% had farm sizes of less than one hectare with about 28% having 6-10 years farming experience. Also, about 71% respondents do not have access to credit facilities. The study established that about 84% of respondents agree that HIV/AIDS significantly affects their crops output and income at 5% level of significance. It was concluded that HIV/AIDS has significant economic effects on crops output and income of the respondents implying that there might be a diverted attention, time and money in nursing the HIV/AIDS patients and burial or funeral services instead of on crop production. Consequently, direct support and supply of credit facilities and inputs need promptly at highly subsidized rate, special package and programs towards improving women income and legislation that can protect the land rights of women and children who contribute in a great measure to crop production development in Nigeria.

Key words: Effects, Youth, Women, HIV/AIDS, Crop Farmers, Kaduna State.

INTRODUCTION

HIV/AIDS spread has brought a significant stress on the crop production affecting the crop output, income and level of living of farmers negatively which posed a major challenge to the economic development of the nation and livelihood generally (La'ah, 2003).In spite of all the efforts being put in by government at all levels as well as non-government organizations and religious bodies, there is still increased reported cases of HIV/AIDs related diseases in Kaduna State (Cross Roads, 2001) with a number of people dying daily.study areas; Little work has been done on effects of HIV/AIDS on crop production, for example, La'ah (2003) in a study titled "The Demographic and Socio-Economic Effects of HIV/AIDS in Kaduna State" Therefore, this study aims at analysing the effects of HIV/AIDS on crop production among youth and women in Jema'a and Giwa Local Government Areas of Kaduna State. Given this background, this study to analyse the effects of HIV/AIDS among youth and women in crop production in Jema'a and Giwa Local Government Areas of Kaduna State, Nigeria., with the specific objective to identify the socio-economic characteristics of HIV/AIDS infected youth and women farmers in the study area; and analyse the effects of HIV/AIDS on (crops output, income and level of living) of youth and women in the study area. Hypotheses: There is no significant difference between the effect of HIV/AIDS among youth and women of their crops output in the study area.

METHODOLOGY

Primary data were collected through the use of structured questionnaire.Purposive sampling procedure was adopted because of the presence of HIV/AIDS in the study areas. The population of HIV/AIDS infected men, women and youth for Jema'a = 1,295, for Giwa = 626, i.e. a total of 1,921 victims and 192 were taken as the sample size. Data collected for the study were analyzed using descriptive statistics to achieve objectives i, analysis of variance (ANOVA) was used to test hypotheses i, and achieved objective ii,

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

The result in Table 2a shows that out of the total respondents of 186, age 35 and above was 41.8% women, while youth who fall between the age of 16 – 34 were about 58.2%. The age range reveals that the youth were the dominant group among the respondents. This agreed with the study of La'ah (2015) who opined that youth were people who are at the stage of their productive or active age (15-34 years) and can engage in any aspect of agricultural production and also active in sex relation.The results in Table 2a revealed that most of the respondents (46.3%) had household size of between 6-10 persons, 32.5% had 1-5 persons and 21.0% had 11-20 persons, therefore the mean of house hold size in this study is 7.7. This implies that the large household size has the capacity to supply some of the labour requirement on farm and the other household activities as affirmed by Solomon (2008) and Banmeke (2003). Farm size is shown in Table 2a. The result revealed that 40,6% of the respondents had farm size of less than one hectare, and farming experience revealed that majority of the respondents (28.9%) had between 6-10 years farming experience,the farming experience of majority of the respondents is about 10 years and may be due to the relatively youthful status of the respondents.This finding is consistent with Igbago (2008) that work experience is not only defined by the length of time work done within the given period. The results in Table 2a indicates that 70.5% earned between ₦1000-₦ 15,000 per month; while 3.2% earned ₦ 61,000 and above per month respectively. The mean in this study is N12, 595.1. This means that the respondents were low income earners, their low income level, may attribute some of them moving into prostitution especially among the females in order to earn a living.

Table 2a: Distribution of Respondents According to Socio-economic Variables.

Socio-economic Variable	Giwa	Jema'a	Overall	Mean	Std.Dev

	Freq	%	Freq	%	Freq	%		
Age group(yrs)								
16-22	15	23.1	14	11.6	29	15.6	33.1	9.6
23-26	06	9.1	12	10	18	9.7		
27-30	22	32.3	18	14.9	40	21.5		
31-34	07	10.8	14	11.6	21	11.4		
35-40	13	20	32	26.4	45	24.2		
41-45	1	15	9	7.5	10	5.3		
46-50	1	15	15	12.5	16	8.7		
51-Above	-	-	7	49	7	3.6		
Total	**65**	**100**	**121**	**100**	**186**	**100**		
Household size								
1-5	16	26.2	38	36.2	54	32.5	7.7	4.1
6-10	31	50.8	46	43.7	77	46.3		
11-20	14	22.9	21	20.2	35	21		
Total	**65**	**100**	**105**	**100**	**166**	**100**		
Farm size(ha)								
0.1-1.0	8	80	33	36.3	41	40.6	2.8	1.8
1.1-2.0	2	20	10	11	12	11.9		
2.1-3.0	-	0	10	11	10	9.9		
3.1-4.0	-	0	15	16.5	15	14.9		
4.1-5.0	-	0	13	14.3	13	12.9		
Above 5	-	0	10	11	10	9.9		
Total	**10**	**100**	**91**	**100**	**101**	**100**		
Farming experience(yrs)								
1-5	2	20	25	28.6	27	22.8	13.1	9.8
6-10	4	40	24	27.6	28	28.9		
11-15	3	30	10	11.4	13	13.3		
16-20	0	0	11	12.5	11	11.3		
21-30	1	10	13	14.8	14	14.6		
31-above	0	0	4	4.4	4	4.0		
Total	**10**	**100**	**100**	**100**	**110**	**100**		
Monthly income								
1,000-15,000	52	82.7	41	55.2	93	70.5	12,595.1	17,251.0
16,000-30,000	8	12.8	12	17.3	20	15.3		
31,000-45,000	-	0	7	9.9	7	7		
46,000-60,000	1	1.6	5	7.1	6	4.7		
61,000-above	-	0	4	5.6	4	3.2		
Total	**61**	**100**	**69**	**100**	**130**	**100**		

Field survey, 2020.

Effects of HIV/AIDS on crops output, income and level of living of youth and women farmers.

In Giwa, 76.9% of the respondents (male, female and youth) agreed that income, females formed 8.9% of the total sample. Out of this, 70.6% agreed that HIV/AIDS affects their income, level of living and crops output, while 29.4% disagreed. Giwa males form 4.7% of total sample Youth form the majority of the respondents in Giwa with 63%. Agree that HIV/AIDS affects their income, level of living and crops output while only 24% did not agree (Table 3.). In Jema'a, 90.5% of the respondents agreed that income, level of living and crops output were affected by HIV/AIDS, while 9.6% disagreed. Jema'a female form 18.2% of the total sample.

Out of this all (100%) agreed that HIV/AIDS affect their income, level of living and crops output. Jema'a males' form 21.4% of the total sample, 75.6% of them agreed that HIV/AIDS affects their income, level of living and crops output while 24.4% disagreed. Youth from Jema'a form 53.1% of the total sample. 93.1% of them agreed that HIV/AIDS affects their income, level of living and crops output, while 6.9% disagreed (Table 3.). Also, the pooled analysis of variance on effect of HIV/AIDS on crops output result in Table 4 shows that there is a significance difference of crops output among the respondents at 5% level of significances, calculated F = 9.569 is greater than the Table F = 3.33. In the case of income, pooled analysis of variance result in Table 5 shows that there is a significance difference of income among the respondents at 5% level of significances, calculated F = 4.056 is greater than the Table F = 3.33. Whereas, the pooled analysis of variance on effect of HIV/AIDS on level of living result in Table 6 shows that no significance difference in level of living exist among the respondents at 5% level of significances, calculated F = 0.21 is less than the Table F = 3.33. This study agrees with the study of Mather *et al*. (2004) which shows that cash, livestock, assets, total and per adult equivalent income were lower for households experiencing death in Mozambique as a result of HIV/AIDS infection.

Table 3: Distribution of respondents according to effects of HIV/AIDS on crops output, income and level of living

LGA	**Respondents**	**Effect Indicators**	**Agree**		**Disagree**		**Grand Total**	
			Freq	%	Freq	%	Freq	%
GIWA	Female	Income	4	80.00	1	20.00	5	2.60
		Level of living	4	66.67	2	33.33	6	3.13
		Output	4	66.67	2	33.33	6	3.13
	Female Total		**12**	**70.59**	**5**	**29.41**	**17**	**8.85**
	Male	Income	3	100.00	0	0.00	3	1.56
		Level of living	3	100.00	0	0.00	3	1.56
		Output	3	1500.00	0	0.00	3	1.56
	Male Total		**9**	**100**	**0**	**0.00**	**9**	**4.69**
	Youth	Income	32	82.05	7	17.95	39	20.31
		Level of living	35	77.78	10	22.22	45	23.44
		Output	25	67.57	12	32.43	37	19.27
	Youth Total		**92**	**76.03**	**29**	**23.97**	**121**	**63.02**
GIWA Total			**113**	**76.87**	**34**	**23.13**	**147**	**76.56**
JEMA'A	Female	Income	9	100.00	0	0.00	9	4.69
		Level of living	12	100.00	0	0.00	12	6.12
		Output	14	100.00	0	0.00	14	7.29
	Female Total		**35**	**100**	**0**	**0.00**	**35**	**18.23**
	Male	Income	9	69.23	4	30.77	13	6.77
		Level of living	10	76.92	3	23.08	13	6.77
		Output	12	80.00	3	20.00	15	7.81
	Male Total		**31**	**75.61**	**10**	**24.39**	**41**	**21.35**

	Youth	Income	32	94.12	2	5.88	34	17.71
		Level of living	33	94.29	2	5.71	35	18.23
		Output	30	90.91	3	9.09	33	17.19
	Youth Total		**95**	**93.14**	**7**	**6.86**	**102**	**53.13**
JEMA'A Total			**161**	**90.45**	**17**	**9.55**	**178**	**92.71**
GRAND TOTAL			**27**	**84.31**	**51**	**15.69**	**325**	**169.27**

Pooled test of the effect of HIV/AIDS on crops output

The null hypothesis which states that "there is no significant difference among men, women and youth infected with HIV/AIDS in their crops output in the study area" was tested and the result is presented in Table 4. It shows that there is a significant difference among men, women and youth crops output at 5% level of significance, this is because the calculated F = 9.569 is greater than the Table F = 3.33. There are two groups of significant difference among the respondents. First, female and youth groups on one hand are not significantly different at 5% level of significance from each other. This is due to the fact that women form the bulk of the youth group. Secondly, on the other hand, the Male group is significantly different from the female and youth groups at 5% level of significance. The male average crops output was 4,516.67kg followed by youth group with average crops output of 1,152.63kg. Female group had the least average crops output, 788.20kg. Although Female and Youth groups are not significantly different, the youth group crops output is higher than that of the female group; therefore, the null hypothesis is rejected

Table 4: Pooled ANOVA Test of crops output among Men, Women, and Youth in the Study Area.

Sources of variation	DF	Sum of Squares	Mean Square	F	Sig
Between Groups	2	33,980,000.00	16,990,000.00	9.569	.001
Within Groups	29	51,490,000.00	1,775,547.47		
Total	31	85,470,000.00			

Duncan multiple range test

	Mean	Std. Deviation	Std. Error
Female	788	546.89	46.45
Youth	1,152.63	1,162.55	37.29
Male	4,516.67	3,497.98	287.51

Different superscripted letters: The mean difference is significant at the 0.05 level Df=2/29, F=9.569, Sig=0.001

CONCLUSION AND RECOMMENDATION

Based on the result of the ANOVA test on effects of the HIV/AIDS on crops output, level of living and income, it concluded that HIV/AIDS has significant economic effects on crops output and income of the respondents in the study area It was recommended that,enlightenment campaign on abstinence should be intensified and use of condoms if abstinence is not possible should be the best alternative for this active stubborn group;provision of credit facilities and inputs should be directly delivered to the effected HIV/AIDS farmers in good time and legislation that can protect the land rights of women and children. This may help to improve the income levels of women who in a great measure contribute to crop production development in Nigeria.

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Impact of cocoyam value added technologies on food security status of women farmers in South-east, Nigeria

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ABSTRACT
Stemming from twin impacts of climate change and Covid-19 pandemic, food insecurity is expected to worsen globally especially among developing countries unless adequate measures are taken to curb the menace. The study assessed impact of adoption of cocoyam value added technologies on food security status of women farmers in South-east Nigeria. 240 respondents were randomly selected Descriptive statistics, adoption scale index, food security index and z-test were used to analyze data. The results of data analysis showed that there was low adoption of cocoyam value added technologies among women cocoyam farmers. Also, about 58.1% of the women farmers were food insecure, while food insecurity gap and severity values were 0.633 and 0.392 respectively. Adoption of cocoyam value added technologies impacted significantly on women farmers income and food security status. It was recommended that deliberate efforts should be made by relevant government agencies to sensitize women farmers in mass and train them on available value added technologies.
Keywords: Cocoyam, food security, value addition, women

1.1 INTRODUCTION
Food is a basic need of humans and food security is central to sustainable development. The international community has long been concerned about eradication of hunger and undernourishment especially among vulnerable groups. However, despite resolution to enhance food security globally, report on world food insecurity highlighted that number of people suffering from hunger globally has increased every year since 1996 (Ijioma, Osondu and Okoronkwo, 2018). Number of people estimated to face food insecurity globally due to the twin impacts of climate change and COVID-19,was projected to double by the end of 2020 (Rondeau, Brianna and Franque, 2020). In a world that seems to be off-track to achieve sustainable development goals by 2030, the growing problem of food insecurity portends a

significant challenge (United Nations, 2020). Food security and insecurity are terms used to describe whether or not individuals, households or an entire nation have access or not to sufficient quality and quantity of food (Osondu, 2018). Many countries including Nigeria are currently faced with the hydra-headed problem of food insecurity and climate change amid the COVID-19 pandemic (Echendu, 2022). In order to solve the problem of food insecurity in Nigeria, especially in this recent time of rise in food prices, there is need to reduce post harvest losses and ensure supply of basic food products at prices within the reach of consumers. One major staple food among rural and urban dwellers in Nigeria, which much attention seems not to have been given is cocoyam.

Cocoyam (*Colocasia* and *Xanthosoma* spp.) is among the world's six most important root and tuber crops (Food and Agriculture Organization (FAO), 2012). Nigeria is the world largest producer of cocoyam accounting for 34% of the world production (FAO, 2013). Cocoyam ranks third in importance after cassava and yam in extent of production among root and tuber crops of economic value in Nigeria (FAO, 2006). It is an important staple crop cultivated mainly in south eastern part of Nigeria mostly by women who usually intercrop cocoyam with other crops (Ojiako, Asumugha, Ezedinma and Uzokiwe, 2007). Cocoyam is mostly used for human consumption and serves as an important food security crop in times of failure or shortage of other crops. However, as is the case with most agricultural produce, cocoyam is highly perishable, hence cocoyam farmers (mostly women) a times do not get the anticipated reward for their work as some of their produce are lost few days after harvest. Kwagala (2018) noted that in developing countries, post-harvest loss is one of the major causes of low agricultural performance and food insecurity amongst farming communities. High level of post-harvest loss reduce the incomes of producers, especially smallholder farmers, which negatively impacts their households' well-being, making them more vulnerable to food insecurity (Barakat, 2018). Participation of smallholders in value chain markets is expected to contribute significantly to rural economic growth, food security and poverty reduction in developing nations

Acting on its national mandate to research into root and tuber crops, the National Root Crop Research Institute (NRCRI), Umudike has developed and disseminated various cocoyam value added technologies aimed at adding economic value to the crop, reducing associated post-harvest losses and possibly widening its market performance. It is envisaged that adoption of these value added technologies will improve food security status of farmers, as well as ensure that cocoyam can be put to wider uses for generation of income. The added income earned from value addition activities can be used to assess food items not produced by farming households, thus improving food security status of such households. This study intends to: (i) describe socio-economic characteristics of women cocoyam farmers in South-east Nigeria; (ii) assess their level of adoption of cocoyam value added technologies; (iii) assess their food security status; (iv) determine impact of adoption of cocoyam value added technologies on income and food security status of the women cocoyam farmers.

2.1 METHODOLOGY

The study was conducted in South-east geo-political zone of Nigeria where greater percentage of cocoyam production takes place (Ojiako *et al.*, 2007). South-east Nigeria is made up of five states namely Abia, Anambra, Ebonyi, Enugu and Imo States. The study area is located between Latitudes $5^0 06'$N and $6^0 34'$N of the Equator and Longitudes $6^0 38'$ E and $8^0 08'$ E of the Greenwich Meridian. According to National Population Commission (NPC), (2007), the population of Southeast zone of Nigeria was 16,381,729 persons.

Multi-stage random sampling technique was used to select sampling locations and respondents for the study. Firstly, 3 of the 5 states in South-east Nigeria, were selected at random. Secondly, 4 Agricultural Development Project (ADP) blocks were selected from each of the 3 states, to

give 12 ADP blocks. Deliberate effort was undertaken to ensure that the selected ADP blocks were spread across the agricultural zones of the states. Thirdly, 2 extension circles were randomly selected from each of the 12 ADP blocks. to give 24 circles. List of women cocoyam farmers in the selected circles was prepared with the help of extension agents domiciled in each of the circles. Lastly, 10 women cocoyam farmers were randomly selected from each of the circles to give 240 women cocoyam farmers who served as respondents for the study.
The study made use of primary data collected from the respondents using pre-tested and structured questionnaire. Analysis of data were undertaken using descriptive statistics, adoption scale index, food security index and z-test.
Level of adoption of cocoyam value added innovations (objective ii), was determined using adoption scale index. It was achieved with the aid of a 7 point Likert type scale graded thus; unaware = 0, Aware = 1, interest = 2, evaluation= 3 trial = 4, accept = 5 and satisfaction = 6. In accordance with Okoye *et al*., (2009) the mean adoption level was determined as follows:

$$\overline{X_s} = \frac{\Sigma x}{n} \quad \ldots \quad (1)$$

Mean score was computed by multiplying the frequency of each response pattern with its appropriate nominal value and dividing same with the number of respondents to the terms. This is summarized with the equation below as follows: $\overline{X_s} = \frac{\Sigma fn}{nr}$ … (2)

Where: $\bar{X}$ =Mean score; $\sum$ = summation; F = frequency; n = Likert nominal value; nr = Number of respondents

Food security status was estimated as the two-thirds of the mean per capita monthly food expenditure of all the women cocoyam farmers. The women farmers were classified into either food secure or food insecure based on the food security line. Those whose monthly food expenditure falls below two-thirds of the mean monthly food expenditure were classified as food insecure, while those whose monthly food expenditure is above or equal to two-thirds of the mean food expenditure were classified as food secure (Osondu, 2018).
Adopting the method of estimation of the Foster, Greer and Thorbecke poverty index, the food security index was estimated following method used by Osondu (2018) as follows:

$$P\alpha = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z-Yi}{z}\right)^{\alpha} \ldots \quad (3)$$

Where: $P\alpha$ = Food security index; z = Food security line (2/3 mean food expenditure); yi = Per food expenditure (i = 1, 2 ....q); N = Total number of farmers; q = Number of food insecure farmers; α = is the aversion parameter that takes values of 0, 1 or 2 that is $\alpha \geq 0$
When α = 0, the FGT index P_0 measures food insecurity incidence. When α = 1, the FGT index P_1 measures food insecurity depth of the farmers. When α = 2, the FGT index P_2 measures the severity of food insecurity. Z- test was used to assess impact of adoption of cocoyam value added technologies on the income and food security status of women cocoyam farmers The Z-test model is expressed below as follows:

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \ldots \quad (4)$$

Where: $\bar{X}_1$= Sample mean of monthly income/food expenditure of adopters of cocoyam value added technologies; $\bar{X}_2$= Sample mean of monthly income/food expenditure of non-adopters of cocoyam value added technologies; S_1^2= Sample variance of monthly income/food expenditure of adopters of cocoyam value added technologies; S_2^2= Sample variance of monthly income/food expenditure of non-adopters of cocoyam value added technologies; n_1=

number of women farmers who adopted cocoyam value added technologies; n_2= number of women farmers who did not adopt cocoyam value added technologies

3.0 RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Women Cocoyam Farmers

Table 1 shows distribution of the respondents according to socio-economic characteristics. The table shows that mean age and farm size of the respondents were 51 years and 0.65 hectare respectively. The mean age suggests that the farmers were still energetic and active and thus, capable of withstanding the physical labour and stress associated with cocoyam farming and value addition activities. The respondents had mean household size of 7 persons. This is good as household members could help in works in the farm enterprise and associated value addition activities if any, thus reducing cost of hired labour. Olagunju (2007) asserted that household size had significant and positive effect on provision of labour and that larger households faced lessened labour constraints during adoption of new technologies. The women farmers earned annual income of 182,241.62 Naira. The income households earn have positive implications on their adoption of innovations, welfare and economic access to food (Osondu, 2018). Meanwhile, 87.08% of the respondents attained diverse level of formal education. Ayode (2013) asserted that education plays positive role in adoption of innovations.

Table 1: Distribution of the women cocoyam farmers according to socio-economic characteristics

Variables	Mean
Age (years)	51.37
Farm size (Hectares)	0.65
Household size (number of persons)	6.78
Annual income (Naira)	182,241.62
Education level	**Percentage (%)**
No formal Education	12.92
Primary education	30.00
Secondary education	50.83
Tertiary education	6.25

Source: Field survey, 2022

3.2 Level of Adoption of Cocoyam Value Added Technologies

Level of adoption of cocoyam value added technologies by the respondents as presented in Table 2 shows that only cocoyam flour ($\bar{X}$ = 3.03) can be adjudged as been adopted. This is not surprising as cocoyam flour is the foremost cocoyam value added technology developed traditionally in South-east Nigeria and often used for soup thickening. Among the cocoyam value added technologies developed by NRCRI none can be adjudged as having being generally adopted by women cocoyam farmers in the area. This result implies that despite the efforts undertaken by NRCRI to disseminate these value added technologies to the rural populace most women cocoyam farmers were still non-adopters.

Table 2: Level of adoption of cocoyam value added technologies by women cocoyam farmers

Value Added Technologies	Unaware (0)	Aware (1)	Interest (2)	Evaluation (3)	Trial (4)	Accept (5)	satisfaction (6)	Total	Mean Score
Cocoyam chips	89(0)	27(27)	19(38)	24(72)	11(44)	29(145)	41 (246)	572	2.38

Cocoyam cakes	151(0)	30(30)	12(24)	5(15)	13(12)	9(45)	20 (120)	286	1.19
Cocoyam bread	174 (0)	8(8)	8(16)	16(48)	10(40)	7 (35)	17 (102)	249	1.04
Cocoyam biscuit	152(0)	20(20)	16(32)	13(39)	18(72)	8(40)	13 (78)	281	1.17
Cocoyam flour	21 (0)	29(29)	45(90)	57(171)	35(140)	22(110)	31 (186)	726	3.03
Croquette	172 (0)	13(13)	10(20)	10(30)	13(52)	9(45)	14 (84)	244	1.02
Chin-chin	132(0)	29(29)	26(52)	20(60)	11(44)	7(95)	15 (90)	370	1.54

Source: Field survey, 2022

Decision Rule: mean score of 1.0 – 1.49 = Awareness stage of the technology; 1.5 – 1.99 = Interest stage; 2.0 – 2.49 = Evaluation stage; 2.50 – 2.99 = Trial stage; and 3.0 and above = Adopted stage of the technology. Figures in parentheses are Likert scores.

3.3 Food Security Status of Women Cocoyam Farmers

Table 3 shows estimates of indices of food security among the respondents. The food security line was estimated to be 4941.88 Naira. Hence, women cocoyam farmers whose household per capita food expenditure was below 4941.88 Naira monthly were classified as food insecure, while those with food expenditures equal or above the food security line were food secure. The food insecurity incidence (P_0) showed that 58.1% of the women cocoyam farmers were food insecure, while the food insecurity gap (P_1) showed that on the average, a food insecure women cocoyam farmer will require additional per capita food expenditure of 3128.21 Naira (0.433 x 4941.88) to exit food insecurity. The value of food insecurity severity (P_2) was 0.392, implying that there was 39.20% inequality among the food insecure farmers.

Table 3: Computed food security indices of the women cocoyam farmers

Food security indices	Women farmers
Mean monthly food expenditure	22512.24
Mean per capita food expenditure (MPCHHFE)	7412.82
Food security line (2/3 of MPCHHFE)	4941.88
P_0 (Incidence of food insecurity)	0.581
P_1 (Gap or depth of food insecurity)	0.633
P_2 (Severity of food insecurity)	0.392

Source: *Field survey, 2022*

3.4 Impact of Adoption of Cocoyam Value Added Technologies on Food Security Status of Women Cocoyam Farmers

The z-test analysis of the impact of adoption of cocoyam value added technologies on the women cocoyam farmers' income and food security status is shown in Table 4. As adduced from the table, adopters of cocoyam value added technologies had significantly higher monthly income and food expenditures at 5.0% and 10.0% alpha levels respectively, implying that adoption of cocoyam value added technologies impacted positively on income and food security status of the women farmers. Findings by Agoh (2018) revealed that adoption of value added technologies had significant positive impact on welfare of sweet potato farmers in Abia State, Nigeria.

Table 4: Impact of adoption of cocoyam value added technologies on income and food security status (number of adopters = 87; non-adopters = 153)

Variables	Individual mean	Mean difference	Standard error	z-value	Sig (2-tailed)
Mean monthly income of adopters	17,714.29				
		5,054.98	3817.62	2.252**	0.033
Mean monthly income of non-adopters	12,659.31				
Mean monthly food expenditure of adopters	9,310.02				
		3, 3794.40	2146.33	1.978*	0.051
Mean monthly food expenditure of non-adopters	5,515.62				

***Source**: Field survey data, 2022*
**, * = significant at 5.0%, and 10.0% alpha levels respectively

4.1 CONCLUSION AND RECOMMENDATION

The study showed that huge gap exists in adoption of cocoyam value added technologies amongst women cocoyam farmers in the area. The few women farmers who were adopters of cocoyam value technologies recorded significantly higher monthly income and food expenditures, implying that adoption of cocoyam value added technologies impacted positively on income and food security status. Based on findings the following recommendations suffice: As part of government effort to curb rise in food insecurity in the country, deliberate efforts should be undertaken by relevant agencies to create more awareness on available cocoyam value added technologies. Women farmers need to be sensitized and exposed to trainings on cocoyam value added technologies. To this end, seminars on value added technologies should be held in designated venues in all rural communities of the study area. Attempts should be made to motivate women farmers to attend in mass. NRCRI, Umudike and Agricultural Development Programme (ADP) should intensify efforts in training women farmers on value added technologies. Women farmers should be encouraged to form and belong to cooperative societies. This will avail them access to various opportunities such as training, credit facilities, inputs and markets.

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Contribution Of International Fund For Agricultural Development (Ifad) To Food Security Status Of Youth Rice Farmers In Ogun State

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ABSTRACT
Support services which is part of IFAD programme is a required incentive to increase youths motivation and participation in rice production as well as improve rice production potentials with measurable impacts on the food security status and livelihood of the youth rice farmers. Therefore contribution of International Fund for Agricultural Development Value Chain Development Program (IFAD) to food security status among youth rice farmers in Ogun State was investigated in this study. Multi-stage sampling procedure was adopted to sample 127 youth rice farmers from two randomly selected local government areas. This gave selection of Obafemi Owode and Yewa North Local Government in Ogun State. Lists of registered members (youth rice farmers) in each of the local government were obtained and 50% of members were systematically selected. Structured questionnaire and interview schedule was used to elicit response on respondents' IFAD support services, constraints encountered by youth rice farmer and food security status of youth rice farmers. Data were analyzed using descriptive (frequency counts, percentages, mean and standard deviation) and inferential(Pearson Product Moment Correlation and Regression) statistics at $p = 0.05$. All of the respondents (100%) had access to IFAD support services in terms of farm input, Good Agricultural Practices (GAP), infrastructural support and institutional linkages except farm assets with (99.2%). Scarcity of land ($\bar{x}$= 17.3), bird infestation on the field ($\bar{x}$= 17.2), market price fluctuation and water shortage ($\bar{x}$= 16.5), untimely delivery of input ($\bar{x}$= 16.4) were the major constraints encountered by youth rice farmers. More than half of the respondents (53.54%) were food secured in the study area. Years of farming experience ($\beta = .253$, $p < 0.036$) and benefit derived ($\beta = .223$, $p<0.022$) significantly influenced the food security of farmers. It is therefore recommended that there is need to provide solution to the scarcity of land by producing adequate land for farmers to cultivate.
Keywords: Contribution, Youth, Food security, IFAD.

INTRODUCTION
The rate of unemployment in Nigeria has continued to be on the increase despite the abundant human and natural resources available in the country. In recent times in Nigeria, addressing the challenges of youth unemployment in the region have become a topical discussion. According

to Filmer and Fox, (2014), efforts to accelerate agricultural growth and improve food security cannot be separated from efforts to create job opportunities for the young people. Hence, governments, organizations are making frantic efforts to stimulate investment and promote youth participation in agricultural value chain activities. Rice is a prominent crop value chain with potential for food security, economic development job creation through improved productivity and import substitution. Increasing rice production and upgrading the rice value chain will increase food security, reduce urban migration, reduce reliance on imports, and provide viable employments for the youths (CICIAR, 2018). Rice is the most-demanded food product traded in the highest quantities in Nigeria (Veldeand Maertens,2014). There are several factors that hampers profitability from rice farming such as inefficient and ineffective agricultural support services delivery like input, low cultivation, climate change, low yield gap, poor infrastructural facilities among others. Addressing the challenges of productivity along the rice value chain could unlock the potential for young rice farmers engaged in its production practices to meet their food and income needs. The Nigeria Agricultural Transformation Agenda ATA (2011-2014), Anchor Borrowers Programme (2015-Date) and other agricultural intervention programmes have sought to improve rice farming to stimulate productivity and create jobs opportunities along the value chain in Nigeria. Likewise, the International Fund for Agricultural Development(2015-2021) emphasize that the potential returns of investments in young people includes food security, poverty reduction, job creation, peace and political stability (IFAD, 2016). The IFAD supports the young rice farmers as crucial target group for employment creation, through their involvement in sustainable agricultural entrepreneurship by providing inputs and support services for youths engaged in the production, processing, and marketing of rice (IFAD, 2012). Accessibility to input support services is a required incentive to increase youths motivation and participation in the rice production as well as improve rice production potentials with measurable impacts on the food security status and livelihood of the youth rice farmers. It is expected that with access to input and others supports, the productivity of the young rice farmers should impact positively on the improvement of their food security status and livelihood at large. .Hence, this study. The general objective of the study is to analyse the contributions of IFAD to the food security status of young rice farmers in Ogun State. The specific objectives are to: ascertain the IFAD supports services accessible in Ogun State;identify the constraints encountered by the youth rice farmers in Ogun State and ascertain the contributions of IFAD to food security of the youth rice farmers in Ogun State.

METHODOLOGY

This study was conducted in Ogun State in SouthWest, Nigeria.A multi-stage sampling procedure was adopted in this study. The first stage involved the selection of Ogun state in SouthWest, Nigeria, being the only state in SouthWest that meets the criteria for the implementation of the IFAD in Nigeria. IFAD was implemented in just eight local government areas in Ogun state namely Obafemi-owode, Ifo, Yewa-North, Ijebu North-East, and Ijebu-East, Yewa-South, Obada, Odogbolu local government areas.The second stage involved random selection of twenty five percent of all the eight local government areas which equals two LGAs, where the IFAD was implemented namely; Obafemi-owode and Yewa North local government areas. The two LGAs were selected based on high concentration of IFAD youth rice farmers in the areas. The third stage involved purposive selection of all the communities in the local government areas selected. Eggua, Alapako, Igbogila and Sanwojo in YewaNorth and Kobape, Ajana-Odo, Ofada and Maloko-asipa in Obafemi-Owode. A list of young rice farmers groups was generated from the IFAD and from the ADP office at each local government area. The list presented 71 rice youth farmers in Obafemi-owode and 181 rice youth farmers inYewa North local government areas. The fourth stage involved proportionate sampling of 50% of the respondents to give 36 and 91 respondents in Obafemi-Owode and

Yewa-North respectively. A total number of 127registered IFAD young rice farmers was sampled. Structured interview schedule and questionnaire were used to elicit information from respondents. Data were analysed using descriptive statistics and Regression techniques

RESULTS AND DISCUSSION

IFAD support services

The result of the findings in Table 1 reveals that all the respondents (100%) received support services in terms of farm inputs, good agricultural practices, infrastructural support, and institutional linkage/ extension service while 99.2% of the respondents had farm asset support. The provision of farm inputs/extension services is one of the core objectives of IFAD to educate rice farmers on the improved method of rice farming. IFAD provided input support services (such as certified seeds, fertilizer, sprayer, agro chemical, bird scaring equipment, flash bottom boiler).Good Agricultural Practices (GAP) training (on land preparation, seed planting, rice transplanting, pesticides and fertilizer application, weed control, insect, pest control, proper harvesting, drying, storage practices, use of weights or measure, seed production, book keeping), farm asset (such as tractor, plough, threshers, power tiller, mechanical harvesters), infrastructures such as pipe borne water, water pumps and hose, markets and feeder roads, storage facilities and machineries, institutional linkages such as off-takers/buyers, ADP, IITA, extension service among others which has improved the farming activities of the rice farmers in the study area. This finding shows that the intervention of IFAD has contributed positively in terms of support services to rice youth farmers in the study area. This finding agrees with that of Oruonye *et al.* (2021) who submitted that the support services majorly received from IFAD program were farm inputs and extension services**.**

Table 1: Distribution of IFAD support services

IFAD support services	Yes	
	Frequency	**Percentage**
Farm Input	127	100%
Gap	127	100%
Farm assets	126	99.2%
Infrastructural Support	127	100%
Institutional Linkage	127	100%

Source:Field survey,2022

Constraints encountered in rice production

The findings in Table 2 shows that the major rice production constraint faced by the youth rice farmers was scarcity of land ($\bar{x}$= 17.3) which ranked first. This could be as a result of problem of land tenure system. This result is not in line with the position of Nkechi et al (2020) and Oloyede (2020) who identified the problem of pests and diseases as the most limiting factor in their study. Bird infestation on the field ($\bar{x}$= 17.2) ranked 2nd. Though the farmers are using electrical and biological method to chase the birds away from the farm land but due to shortage supply of electricity and high cost of maintenance, bird attack the rice which one of the major constraints. Market price fluctuation and water shortage ($\bar{x}$= 16.5) ranked 3rd. This could be as a result of instability of market price and low supply of water in the farm land. Untimely delivery of input ($\bar{x}$= 16.4) ranked 5th. This is one of the major constraints encountered which occur as a result of poor road network. The finding is in conformity with that of Odoemenem and Inakwu (2011) who reported that inadequate capital, high cost of input, high cost of labour amongst others were the major constraints militating against rice production in the study area.

Table 2: Distribution of respondents based on constraints encountered in rice production

Constraints	Not a constraint	Mild constraint	Severe constraint	Weighted mean score	Rank
High cost of input	36.2	59.8	3.9	15.2	12th
Labour access and cost	32.3	56.7	11.0	16.2	6th
High cost of transportation	32.3	58.3	9.4	16.1	8th
Market price of fluctuation	27.6	63.0	9.4	16.5	3rd
Water shortage	26.0	66.1	7.9	16.5	3rd
Untimely delivery of input	26.0	65.4	8.7	16.4	5th
Scarcity of land	22.0	65.4	11.8	17.3	1st
Bird infestation on the field	22.0	66.1	11.8	17.2	2nd
Presence of impurities in rice	29.9	66.1	3.9	15.8	11th
Pest and disease infestation					
Poor frequency of extension agents	26.8	67.7	5.5	16.2	6th
Loss of paddy due to inadequate drying platform	29.1	66.1	4.7	15.9	9th
Farmer offtaker conflict of interest	29.1	66.1	4.7	15.9	9th
Crop destruction by herdsmen					
	37.8	61.4	0.8	14.8	14th
	36.2	59.8	3.9	15.2	12th

Source: Field Survey, 2022

Categorization of level of food security

The categorization of youth rice farmers according to their level of food security presented in Table3 shows that most of the youth rice farmers (53.54%) were food secured compared to (46.46%) that were not food secured. This result implies that more than half of the respondents were food secured in the study area. This finding supports Otunaiya and Ibidunni(2014) who reported that seventy percent of the farming households in Ogun state were food secured.

Table 3: Level of food security

Food security	Frequency	Percentage	Mean	Min. score	Max score
Food secure (9-15)	68	53.54	14.95	9	27
Food insecure (16-27)	59	46.46			
Total	127	100			

Source:FieldSurvey,2022

Hypothesis : There is no significant contribution of independent variables to food security of respondents

Regression analysis in Table4 shows the contribution of selected variables to food security of respondents. The R-square (.510) obtained for youth rice farmers indicates that the selected independent variables contributed 51% to their food security. The result reveals that years of farming experience (β = .253, $p < 0.036$) benefit derived (β = .223, $p<0.022$) significantly influenced the food security of farmers. This is in agreement with *a priori* expectation. This is an indication that farmers are well experienced in their various rice production activities and might have acquired knowledge and skills to improve their food security. The Table also shows that benefit derived have significant contribution of 33% to farmers food security. This mean s that the more farmers make use of IFAD support services, the more the benefits they will derive in order to attain better food security status.

Table 4: Regression analysis of contribution of independent variables to food security of respondents

Variables	B-value	t-value	p-value	Decision
Constant		4.385	.000	
Age	.158	1.141	.256	NS
Sex	.073	.732	.466	NS
Marital status	.132	1.160	.248	NS
Educational status	-.089	-.895	.373	NS
Household size	-.191	-1.869	.064	NS
Income from rice farming per annual	.037	.323	.747	NS
Years of farming experience	.253	2.231	.036	S
Cultivation type	.013	.096	.924	NS
Rice varieties grown	-.005	-.040	.969	NS
Source of land for cultivation	.086	.893	.374	NS
Source of credit	.047	.455	.650	NS
Source of labour	-.005	-.049	.961	NS
Derived benefit	.223	.331	.022	S
Constraints	.004	.048	.962	NS

Source: Data analysis, 2022 S-Significant NS-Not Significant
R = 0.412 R^2 =0 .510 Adjusted R^2 = 0.257
Standard error of estimate = 3.933 Significant at $P<0.05$

CONCLUSIONS AND RECOMMENDATIONS

Respondents had access to IFAD support services. IFAD youth rice farmers derived benefits such as reduced cost of production, increase productivity, employment generation, reduced post harvest loss and availability and access to adequate input among others. Scarcity of land, bird infestation on the field, market price fluctuation, water shortage were the major constraints encountered by the youth rice farmers. More than half of the respondents were food secured in the study area. Years of farming experience and benefit derived were the independent variables that contributed significantly to food security of youth rice farmers. The study recommends that government should make it easier for farmers to access lands for expanding their farms. Farmers who have proven efficiency should be given lands to rent at reduced cost with the option of purchasing such lands at reduced costs over a period of time. Individuals and organizations who have unused lands could partner with farmers who would farm their lands until such a time when the lands are ready for their original purposes. More methods of chasing birds away should be introduced; chemicals like methiocarb which are non -toxic but unpalatable to birds can be introduced to provide solution to the problem of bird infestation of rice field.

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Women Arable Crop Farmers' Adaptation Strategies against Climate Change

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ABSTRACT

This study ascertained the various climate change adaptation measures practiced against climate change by the women arable crop farmers in Ika North East LGA of Delta State, Nigeria. A two-stage random sampling procedure was used to select six communities from each of the LGAs and fifteen women arable crop farmers from each of the sampled community, which gave a total of twelve (12) communities and 180 small scale women arable crop farmers respectively. Data were collected by use of questionnaire which were analysed using Descriptive statistical tools. Different strategies were listed for the respondents to indicate and multiple responses were recorded. The result revealed the following adaptation strategies; early planting (97.8%), crop rotation (96.7%), minimum tillage (80.6%), drought resistant varieties (77.2%), intercropping (76.7%) among others. The study recommends more involvement of extension workers to educate the farmers on better adaptation strategies.

Keywords: Adaptation, Arable Crop Farmer, Climate Change, Productivity.

INTRODUCTION

Climate change is defined as statistically significant weather variations that persist for a long period of time. It could take up to decades or even longer. It involves shifts in the rate of concurrency and therefore the degree of intermittent weather events (Ricardo *et al.,* 2018). Climate change have alternative ways of prevalence. These could be changes in average weather conditions, variations in regional environmental condition factors leading to some drier or wetter areas on average, variations in rainfall events which may become additionally erratic in some regions. Climate change is a massive challenge facing humankind these days as it ends up in a rise within the rate and frequency within the prevalence of utmost weather events which continue to cause threat to food security in some regions, as extreme weather events destroy crops and scale back yields. Climate change also have devastating impact on pastoralist communities though the impact of climate change is felt everywhere in the globe, developing countries and States that have fragile landscapes are the worst affected areas. According to Heshmati (2021), climate change has become an additional threat to human existence because it has become a major challenge to the proper development of socioeconomic activities especially Agriculture. Agriculture remains the backbone of Nigeria's economy, with more than 50% of the active labour force engaged within the sector and providing most of the national food needs for the population (Enfield, 2019). Climate change projections across the globe point to increasing temperatures across all ecological zones, with temperatures during the dry season expected to extend by about 3^0C by 2080 and the most challenge remain principally flooding (NOAA, 2022). As agricultural production in Federal Republic of Nigeria is generally dependent on rainfall, any erratic changes in rainfall and temperature can continuously exert adverse result on her agricultural production because the country has only one rainy season that the agricultural production depends on (Assan, *et al.*, 2018). Ike and Ezeafulukwe (2015) explained that among the results of climate change on agriculture are the reduction in yield, losses in farm income, and a decline in the livelihood and sustainability of farm households. These adverse impacts of climate change may conjointly stifle efforts toward poverty reduction among rural dwellers that depend upon agriculture and different climate-sensitive activities for their livelihoods and well-being. Some other studies in Federal Republic of Nigeria have shown that losses due to the temperature change annually is on the average of 5.5% of total output of some major staple crops such as maize, rice, cassava, yams, millet, sorghum, groundnuts, and plantain (Ogbonna *et al.*, 2017).

Delta State is thought to be an associate agricultural State with agriculture employing over 70% of the agricultural manpower (Ofuoku and Okompu 2022). Thus, it is crucial for farmers to undertake applicable adaptation ways to cushion them against the adverse impacts of climate change. According to Perera *et al.* (2020), climate change adaptation methods are ways that enable individuals or communities to comply with or deal with the impacts of changes in climate. Cultivable crop farming is predominant within the north and central agricultural zones of the State with females being the key players engaged within the production of maize, cassava, plantain and foliate vegetables among others. Ike and Ezeafulukwe (2015) discovered that female small-scale farmers are rather suffering from the challenges arising from changes in climate because of inherent inadequacies. There is gender bias in the nature of vulnerabilities to climate change, which leads us to the main focus of this study which is to: ascertain the various climate change adaptation measures practiced against climate change by the women arable crop farmers in Ika North East and Ika South Local Government Areas of Delta State, Nigeria. It is envisaged that the outcome of this study will inform decision making on effective and appropriate strategies to solving the problem of climate variability

MATERIALS AND METHODS

The study was carried out in Ika North East and Ika South Local Government Areas (LGAs) of Delta State, Nigeria. The two local government areas are among the twenty five (25) Local Government Areas that make up Delta State. They are in the North Agricultural Zone of Delta State. The two Local Government Areas were selected for the study because they are the areas where farming is mostly carried out in Delta North zone and are referred to as the food basket of the State.

A two-stage random sampling procedure was used to select six communities from each of the LGAs and fifteen women arable crop farmers from each of the sampled community, which gave a total of twelve (12) communities and 180 small scale women arable crop farmers respectively. Primary source of data collection through the use of a structured questionnaire was used. The different strategies employed by women small scale arable crop farmers to fight against the challenges of climate change were listed for the respondents to indicate. Descriptive statistical tools such as mean, percentages and frequency tables were used to summarize the data.

RESULTS AND DISCUSSION

According to Kim *et al.* (2018), agriculture is negatively affected by climate change, while adaptation reduces the impact and increase resilience to climate change such that those farmers who adapt are less vulnerable to these negative impacts of climate change. Adaptation strategies employed by the respondents are indicated in Table 1.

The results indicate that; 77.2% of the women arable crop farmers in the area were adapting by using drought resistant varieties, early planting as a strategy for averting the consequences of climate change on their farming activities was employed by over 97% of the respondents. This goes to show the importance of this strategy in checkmating the consequences of climate change in the area. The use of early planting as an adaptation strategy against climate change by large number of farming household has also been reported by Shongwe *et al.* (2014) in their study on Cost Benefit Analysis of Climate Change Adaptation Strategies on Crop Production Systems in Mpolonjeni Area Development Programme (ADP) in Swaziland.

The respondents indicated that they took advantage of early rains as compared to late planting. Two other strategies, minimum tillage (80.6%) and crop rotation (96.7%) were alluded to as among the most effective measure of combating the negative effects of climate change in arable crop production by the respondents. The use of crop rotation as an important method of averting the consequences of climate change has been reported by many researchers.

Table 1: Adaptation Strategies Employed by Women Arable Crop Farmers against Climate Change

Adaptation Strategy Used	Frequency (Did Use)	Percentage (Did Use)	Frequency (Did Not Use)	Percentage (Did Not Use)
Drought resistant varieties	139	77.2	41	22.8
Early planting	176	97.8	4	2.2
Late planting	56	31.1	124	68.9
Minimum tillage	145	80.6	35	19.4
Crop rotation	174	96.7	6	3.3
Mulching	20	11.1	160	88.9
Irrigation	35	19.4	145	80.6
Intercropping	138	76.7	42	23.3

***Multiple responses were recorded**

Adaptation strategies that received the least responses were mulching (11.1%) and irrigation (19.4%). Irrigation involves high capital investment, which can be a challenge to most rural households because of poor financial background. The strategy also needs a good, reliable water source, which is not the case in most communities under study in both Ika North East and Ika South Local Government Areas.

CONCLUSION

The study showed that climate variations has adverse effects on agricultural production particularly female small holder farmers, who now take advantage of some adaptation strategies to mitigate the effect. Some of such strategies are planting improved varieties, minimum tillage, crop rotation among others. The study recommends that for consistent growth in agricultural production, Government at all levels should make agricultural extension programme more effective in order to equip rural women farmers with relevant and timely information and technology to improve their production techniques, climate adaptation measures and increase their income and standard of living.

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Factors influencing children activities in artisanal fishing in five fishing communities in Badagry

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ABSTRACT

Despite the global effort to reduce and totally eradicate child labour, children are very still involve in fishing activities in most fishing communities visited, there contribution are mostly unrecorded in national income. Children contribution in artisanal fishing was investigated between September 2020 and February 2021 to assess the percentage number of children involved in five fishing communities' in badagry, their roles and the outcome of the activities on their livelihood with the use of questionnaire's was documented. Data collected were collated and analysed using frequency distribution and percentages. During the study, no female child was found fishing while male counterpart were totally involve in active fishing, the total numbers of boat counted in five communities where 1,122 and total people counted on the boat where 198 for the period of six month in the various communities. The percentage of children that attended school are 20.43% in September, 18.82% in October, 16.13% in November, 13.44% in December, 18.82% in January and16.13% in February, and their roles includes paddling, bailing water, sorting fish, casting net, setting fishing gears, mending and cleaning of fishing ears used. Enlighten the fisher folks for continuous education of their children is very important. The effort of the children greatly increase fish production and contribute immensely to the artisanal fishing community. The best way to reduce child labour in artisanal fishing is that government should provide the right supports and infrastructures to fisher folks on the ways of improving fishing methods for sustainable management of the fishery to provide for their children education even to tertiary level.

KEYWORDS: Children, fishing, contribution and Badagry

INTRODUCTION

Artisanal fisheries is fishing carried out at subsistence level, by local people using locally dug out wooden canoes, which are usually not motorized while spears, traps, hooks, nets and other locally fabricated traditional gears characterize fishing at this level (Tobor, 1990) Children's activities in fisheries sector have been observed and recorded as far back as the 1960s in Java (White,1976). Quite a sizeable proportion of the Nigerian population depends on fishing as a source of income (Tobor, 1984). Contribution of children in livelihood activities of their households is prevalent in developing countries and Africa in particular as it is regarded as part of the socialization processes to ensure the sustainability of such livelihood activities. Though experts in developed countries consider children's contribution in income generating activities as a form of child labour, it is gradually been agreed to, that not all child's work can be regarded as child labour (ILO, 2005)

METHODOLOGY

This study covered some fishing communities in Badagry. Primary data for the study were collected between the hour of 09.00 and 14.00 GMT on working days for six months (i.e. September, 2020 – February, 2020. questionnaires were used. Data collected were collated and analysed using frequency distribution and percentages. Factors considered were total number of boats fishing, total number of people in the boat, total number of children in the boat, age and educational background of the children in the boat, the children's roles in the boats and the people targeted were fishermen.

RESULTS AND DISCUSSIONS

Table 1: The activities of children and their age in some fishing communities in Badagry

The activities of the children in their various communities includes, paddling, bailing water, sorting fish, casting net, setting fishing gears, mending and cleaning of fishing gears used

ROLES OF CHILDREN	PADDLING	SETTING OF FISHING GEARS	CAST NET	FISHING WITH HOOK /LINE	BALING OF WATER	Sorting of fish	DOING NOTHING	CLEANING /MENDING OF NETS
AGES OF CHILDREN	12-14years	9-11years	15-17 years	15-17 years	3-5years	6-8years	0-2years	15-17YEARS

Table 2: Children in artisanal fishing in some fishing communities in Badagry

Months	Number of boats counted	Total number of people in all the boats	Total Number of Boys	Total Number of Girls	Total number of children in the boat	Crew size of the children sitting in a boat
Sept 2020	214	42	42	0	17	14

Oct 2020	200	39	39	0	34	18
Nov 2020	203	34	34	0	40	24
Dec 2020	180	28	28	0	36	30
Jan 2021	150	28	28	0	35	26
Feb 2021	175	27	27	0	30	22

The total number of boats counted, number of people in the boats counted, number of boats with children, number of children in the boat, number of boys and girls counted crew size of the children sitting in a boat are shown in table 1. The average numbers of boat counted in five communities where 187and people counted was 33 and 32 for children respectively for the period of six month in the various communities. 198 children were interviewed during the period, 153 children answered by themselves while parents answered for 45 children. During the study, no female children was found fishing, while male was 99.9%. (Fakayode *et al*, 2013) recorded a female child fishing in Lagos lagoon, Girls were assisting their mothers in fish processing and marketing, sometimes the female children stay at home to take care of their younger ones.

Table 3: The age range of the children counted in some fishing communities in Badagry

Age range	**0-2years**	**3-5years**	**6-8years**	**9-11years**	**12-14years**	**15-17years**
Number	1	24	168	173	96	6

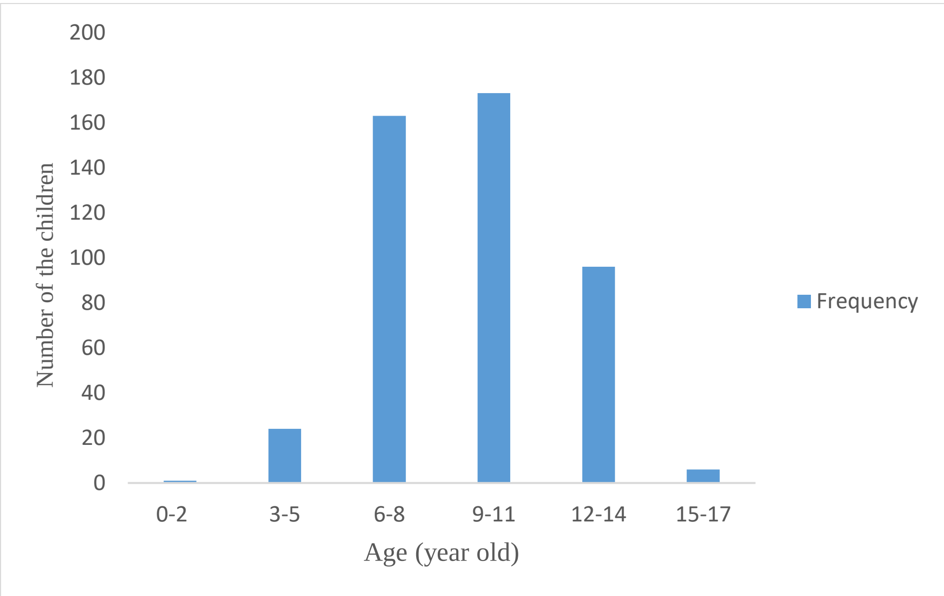

Fig 1: Total number of children at a particular age in the various communities

Table 4: Percentage of children attending School in some fishing communities in Badagry

The percentage of children that attended school were 20.43% in September, 18.82% in October, 16.13% in November, 13.44% in December, 18.82% in January and16.13% in February,

Month	Sept 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021
Children attending school %	20.43	18.82	16.13	13.44	18.82	16.13

CONCLUSION AND RECOMMENDATIONS

The study shows that children, in particular the boys are totally active in fishing in their various communities and contribute to the artisanal fisheries sub sector, also helped in alleviating the poverty status of their households. Contribution of children as revealed may not be affecting children's school enrolment and completion negatively in the area. The contribution of children in the artisanal fishery of some fishing communities in badagry, show great potentiality in terms of natural yield which can help the government effort in employment generation, poverty alleviation, food security and supply of animal protein to the people living in Lagos.

It is recommended that government can increase the right support in terms of aids and infrastructures to fisher folks on the ways of improving fishing methods for sustainable management of the fishery also to support their children education. It was observe that no law would stop the fisher folks to involving their children in fishing and it may jeopardize the effort of government on fish production the right way to reduce child labour in artisanal fishing is that government should provide the right supports and infrastructures to fisher folks on the ways of improving fishing methods for sustainable management of the fishery to provide for their children education even to tertiary level

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Assessment of Women Participation in Yam Production among Farmers in Ebonyi State, Nigeria

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ABSTRACT

The study was conducted among farmers in Ebonyi state to assess the level of women participation in yam production. The study also identified the improved technologies used by women in yam production, the yam varieties grown by women,and the factors constraining against women participation in yam production in Ebonyi State. Data were collected from sixty women farmers from Ebonyi South Agricultural Zone with a well-structured questionnaire. Data collected were analyzed with descriptivestatistics.The result showed that the yam production technologies used by respondents were organic manure (91.67%), inorganic fertilizer (78.33%), minisett (71.67%), improved yam varieties (68.33%), herbicide (66.00%) the result also showed a high level of participation of women in yam production in the study area with the mean of (2.82), an indication that women contribute to food security through yam production. The major constraints in yam participation among women were poor access to credit and climate change (100.00%)and(100.00%). unavailability of fund (96.67%), lack of fertilizer (93.33%) and poor yield (91.67%) In recommendation, efforts shouldbe made to handle these major constraints in women participation, for increasedyam production among women. We also recommend that yam will be seen as men and women crop because women are highly involved in the production.

Keywords;Women, Participation,Yam,Production, Farmers

INTRODUCTION

Yams (Dioscorea spp.) is an annual or perennial tuber-bearing plant, a tropical crop with many species, out of which six are economically important in terms of food and medicine (IITA, 2009). Yam originated in South East Asia and was brought to West Africa in the 16th century. It is one of the principal tuber crops in the Nigeria economy. Nigeria is the leading world producer accounted for over 65% of world yam annually, producing an average of 38 million metric tons (Odinwa *etal*,2016) Yam is an important source of carbohydrate for many people of the Sub Saharan region especially in the yam zones of West Africa. It's the second most important tuber crop in Africa, after cassava, with production reaching above one third of the level of cassava. Yam tuber is essentially a starchy food, its principal nutritional function being the supply of calories to the body (Onwueme,2001).Nigeria accounted for over 65%of world yam annually,producing an average of 38 million metric tons (Odinwa *etal*, 2016) . Yam is regarded as men crop in the Southeast Zone of Nigeria, which may be practically true or not, Women are playing a larger role in yam production in some parts of Nigeria. More women are into yam production and processing, but with limited access to resources (Kathryn *etal*, 2012).Research showed that both men and women plant yam in most part of Nigeria, women even grow yam more than men in some areas, while men engage in drinking of palm wine and other alcohol. In parts of Southeastern Nigeria, men and women combine efforts to do the planting; the women carry out weeding about 2-3 times before harvest; and men and women combine efforts again at crop maturity to harvest and even processing(Kathryn *etal* 2012).Despite high involvement of women in yam production, women experience greater constraints in accessing production resources.It will be good to find out the level of women involvement on yam production in Southeast Nigeria, in order to make references and acknowledge the contribution of women to food security and empowerment in Nigeria.

OBJECTIVES OF THE STUDY

1 Describe the socio economics characteristics of the respondents

2 Ascertain the improved yam technologies used by respondents
3 Identify the improved yam varieties used by respondents
4 Assess the level of participation of women in yam production
5 Identify the constraints in the participation of women in yam production in the study area

METHODOLOGY

The study was conducted in Ebonyi State and the population constitutes all yam producers in Ebonyi State. Multi stage sampling technique was used in the study. Ebonyi South Agricultural Zone was purposively selected for the study because of large number of women yam farmersin the area. In the second stage, twoExtension Blocks,Ivo and Onicha were purposively selected. Three Circles were randomly selected from the blocks. A list of all women yam producers in the selected circles were obtained from theextension agents and community leaders in the area, which formed the sampling frame of the study. From the frame, ten (10) yam women farmers were randomly selected for the study which gave a total of sixty (60) respondents for the study. Data were collected from the women using a questionnaire. Data collected were analyzed with descriptive statistics such as frequency tables, means and percentages. Objective four was realized with 4-point Likert type. Where: Strongly Agree (SA) = 4; Agree (A) = 3, Disagree (D) = 2 and Strongly Disagree (SD) =1. Therefore, the Likert mean $=\frac{4+3+2+1}{4}= 2.5$.

Results and Discussion

Table 1: Distribution of Respondents According to Socio Economic Characteristics

Age	Frequency	Percentage
< 20	1	1.67
20-29	5	8.33
30-39	21	35.00
40-49	12	20.00

50-59	15	25.00
Above 60	6	10.00
Total	**60**	**100**
Mean	**42**	
Marital status		
Single	24	40.00
Married	36	60.00
Total	**60**	**100**
Farm size		
< 1	32	53.33
1-2	8	13.33
3-4	14	23.34
Above 4	6	10.00
Total	**60**	**100**
Mean	**1.9**	

Table 1 shows that most (35.00%) of the respondents were within the age range of 30-39 years. However, the mean age of the respondents in Ebonyi State was 42 years, implying that they were middle aged, experienced and productive. This result is in agreement with Okeke and Udeora (2013) who reported that yam farmers in Southeast Nigeria were between the ages of 40 and 60 years. . Majority (60.00%) of the respondents were married while (40.00%) of them were single. This finding reveals that greater proportion of respondents were married, implying that married women are more involved in yam production than single women. This finding is in tandem with Ufondu, *et al* (2021) who reported that married women dominated yam production and processing business in Ebonyi State..Majority (78.33%) of the respondents had household size of 3-6 persons. On the average, the household size of the respondents in Ebonyi State were 5.3 persons This result revealed that the respondents maintained a relatively sizeable household size which could serve as insurance against shortfalls in labour supply and a source of cheap labour. Although very large family size may constitute a social burden, larger families use their labour input as an advantage in yam production and processing activities.Majority of the womenhad farm size of less than 1ha. On the average, the farm size of the respondents was 1.9ha. This result implies that majority of the respondents are marginal farmers because the cultivated less than 1ha of land. This finding is in agreement with Ofondu *et al.*, (2021) who reported that yam farmers in Ebonyi state cultivated less than 2hactares of land.

Table 2: The Distribution of the Respondents According to the Yam Technologies Used

Indicator	Frequency*	Percentage	Rank
Inorganic fertilizer	47	78.33	2nd

Improved variety	41	68.33	4th
Pesticide	14	23.33	8th
Herbicide	40	66.00	5th
Organic manure	55	91.67	1st
Minisett	43	71.67	3rd
Seed yam	31	51.67	7th
Ware yam	34	56.67	6th

Source: Field Survey, 2021 (Multiple response)

Table 2 presents the improved yam technologies used by the respondents in the study area in their order of magnitude include: seed yam (51.67%) and pesticide (23.33%). . This result could imply that the most common improved yam technology used in Ebonyi State, Nigeria is organic fertilizer. Increased utilization of organic fertilizer could be attributed to the fact that it is cost effective and safe

Table 3: The Distribution of the Respondents According Improved Yam Varieties Planted

Yam	Frequency*	Percentage	Rank
Water yam	57	95.00	1st
Yellow yam	50	83.33	2nd
Three leaf yam	30	50.00	5th
Aerial yam	48	80.00	3rd
White yam	45	75.00	4th

Source: Field Survey, 2021 (Multiple response)

Table 3 shows the improved yam varieties planted by the respondents in the study area in their order of magnitude, these include: water yam (95.00%), yellow yam (88.33%), Aerial yam (80.00%), white yam (75.00%) and three leaf yam (50.00%). This result could imply that the most common improved yam being planted among women are water yam, yellow yam, aerial yam and white yam

Table 4: Mean rating of the level of participation of women in yam production

Indicators	Ebonyi State (n =60)		
	Total	**Mean**	**Decision**
Land clearing	142	2.36	Rejected
Ridging/mounding	133	2.21	Rejected
Planting	205	3.42	Accepted
Weeding	212	3.53	Accepted
Stalking	131	2.18	Rejected
Pest control	197	3.28	Accepted
Fertilizer application	192	3.20	Accepted
Herbicide application	134	2.23	Rejected
Harvesting	176	2.93	Accepted
Grand mean		**2.82**	**Accepted**

Source: Field Survey, 2021. Critical mean score = 2.5. **Decision rule:** Mean ≥ 2.5=Accepted

Table 4 presents the level of participation of women in yam production in Ebonyi State. The grand mean score was 2.82 and was accepted because it was greater than the critical mean value of 2.5. This result implies that the women in Ebonyi state participated to a very high level in yam production. This observation could be a pointer to the fact that women are gaining access to agricultural resources such as land, credit and improved input and are considered to contribute immensely to food security status of their families.

Table 5: The Distribution of the Respondents According to the Constraints in Yam Production

Constraints	Frequency	Percentage	Rank	Frequency	Percentage	Rank
Lack of fertilizer	51	85.00	6th	56	93.33	4th
Unavailability of fund	53	88.33	4th	58	96.67	3rd
Poor yield	50	83.33	7th	55	91.67	5th
Poor access to credit	54	90.00	3rd	60	100.00	1st
Climate change	58	96.67	2nd	60	100.00	2nd

Source: Field Survey, 2021 (Multiple response)

Table 5 presents the constraints in yam production in the study area. The common constraints to yam production in Ebonyi State in their order of magnitude include: Poor access to credit and climate change (100.00%), unavailability of fund (96.67%), lack of fertilizer (93.33%) and poor yield (91.67%). This finding is in line with Nahanga (2015) who reported that the most common challenges for yam production in Nigeria were climate change and low financial base of the farmers.

CONCLUSION

There was high participation of women in yam production , Regarding yam as men crop is no longer justified The most common improved yam technologies used by the respondents was organic manure. The improved yam varieties planted by the respondents in the study area in their order of magnitude include: water yam, yellow yam, aerial yam, white yam and three leaf yam .The level of participation of women in yam production in the study area was very high. The constraints to women participation in yam production in Ebonyi State include: Poor access to credit and climate change, unavailability of fund, lack of fertilizer, poor yield and poor marketing.

RECOMMENDATIONS

Based on the foregoing findings, the following recommendations were made.
Government should aim at solving the major constraints of farmers especially in facilitating access to loans to aid production, making needed inputs available in time and, all subsidized rate, provision for all season, and deployment of experienced extension workers to aid the farmers.The Extension agentsshould intimate the farmers on effective coping strategies for climate change, as this will help to mitigate the effect on yam production

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Farmers' perception of communication behaviour and usefulness of farmer cooperative societies in Abia State, Nigeria

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ABSTRACT

Agriculture is the main occupation of the vast majority of the population of Nigeria. Producers' organizations can help smallholder farmers participate in emerging high- value markets, such as the export market and the unfolding modern retail sector in Nigeria. Farmer Cooperative Societies (FCSs) strengthens support service for small scale farmers by developing link between farmers, processors, marketers and even consumers of agricultural produce. The study was conducted in Abia state. Well-structured questionnaire were used to elicit data from 80 respondents. The data were analyzed using descriptive statistics. The results revealed that the perception among the respondents ranked 'good to excellent'. The perception on communication behaviour and group orientation indicated the extent of interaction among the members (3.83). Group members are actively participating in FCS meeting and other orientation programmes. The level of perception on usefulness and outcomes revealed that FCS helped members to have better family livelihood activities. The results also indicated that after joining FCSs, their economic wellbeing improved. The FCS are playing major role by dissemination of information on recent technologies and new agricultural practices.

Key Words: Perception; Communication behavior; Farmer Cooperative

INTRODUCTION

Agriculture is the main occupation of the vast majority of the population of Nigeria.Various types of agricultural products are produced in Nigeria and the marketing of all these products is a complex process. Farmers do not have access to direct market and are selling their produce to the intermediaries (Nwafor et al., 2019). Because of intermediaries, their profit margin is reduced and their farming business becomes a non-viable one. Improvement in the status of the farmers is possible only through diversification and commercialization of their agricultural activities. This is possible only through implementation of agricultural policy reforms, introducing sustainable agricultural practices, optimizing input efficiency, bringing about institutional change, developing human resources capital and through participation of the non-governmental sector in agriculture. There is a need to strengthen support services for small-scale farmers by developing a link between farmers and purchasers of agricultural produce. Currently, such types of linkages are either not in existence or very weak. It is well recognized that the commercialization of small-scale, resource-poor farmers is closely linked to higher productivity, greater specialization and higher income (Bernard and Spielman, 2009). Perception in this study referred to the process by which one would have interest of communication and group orientation, outcomes and usefulness and overall level of satisfaction through FCS as member

It is possible to mobilize farmers in groups and build their associations called Farmer Producer Organization (FCSs) to plan and implement product specific cluster/ commercial crop cycles. The FCS is a means to bring together the small and marginal farmers and other small producers to build their own business enterprises that will be managed by themselves. The FCS can help farmers in the production of various agricultural produce as well as during the process of marketing of the crops. Farmers' organizations offer small-scale farmers to participate in the market more effectively and collectively, they are in a better position to reduce transaction costs of accessing inputs and outputs, obtaining the necessary market information, securing access to new technologies and to tap into high value markets, allowing them to compete with larger farmers and agribusinesses (Stockbridge *et al*., 2003). This study therefore assessed the perception of farmers on communication behavior and usefulness of Farmer Cooperative Societies (FCS) in improving the livelihood of farm households.

MATERIALS AND METHODS

This study was conducted in Abia State, Nigeria. Multistage sampling technique was adopted. The first stage was the random selection of Ohafia and Umuahia agricultural zones of Abia State. At the second stage, two local governments area were randomly selected from each of the zones-Aba zone; Ohafia zone; Ohafia and Bende local government areas: Umuahia zone; Ikwuano and Umuahia north government areas. Stage three was the random selection of two communities from each of the four local government areas and the last stage was the selection of 10 respondents purposively from each of the selected communities. These selected 80 respondents were the members of farmers' cooperative societies. Descriptive statistics were used to analyse the data.

RESULTS AND DISCUSSION

Perception in terms of communication behaviour and group orientation

The results obtained on perception in terms of communication behaviour and group orientation are presented in Table 1. The perception in terms of communication behaviour and group orientation were categorized under five criteria namely: the extent of interaction among the members, the assigned group activities and assignments given helped in gaining experience, the overall ability to meet farming related activities, the extent of participation in various community welfare activities, obtained some intellectual challenges. Among the five criteria, extent of interaction among the members (3.83) and the assigned group activities and assignments given helped in gaining experience (3.77) had indicating satisfactory to good level of perception. The respondent's perception on the overall ability to meet farming related activities (3.48), while the extent of participation in various community welfare activities and members who obtained some intellectual challenges had a similar mean perception score of 3.41. This implies that there is a positive perception in terms of communication behavior of the cooperative societies in the area. This is in line with the assertions of Tingchang et al (2021) who asserted that people now share their experiences with others through social networking services by posting on Internet forums, websites, or blogs. For example, people frequently use microblogging platforms (e.g., Twitter) to share their everyday happenings with networked others (e.g., followers). People also use electronic word-of-mouth (eWOM) in the form of online shopping website reviews (e.g., Amazon) to share their experiences with a product or service with unknown others (e.g., Amazon users).

Table 1: Perception in terms of communication behaviour and group orientation

S/No	Perception	Mean score	Rank
1	The extent of interaction among the Members	3.83	1st
2	The assigned group activities and assignments given helped in gaining experience	3.77	2nd
3	The overall ability to meet farming related activities	3.48	3rd
4	The extent of participation in various community welfare activities	3.41	4th
5	Obtained some intellectual challenges	3.41	4th

Source: Field survey, 2018

Perception on the usefulness and outcomes among the respondent

The results of the perception on the usefulness of cooperative societies and outcomes among the respondents are presented in Table 2. As shown in the table, the four criteria viz., FCS helped me to have better family livelihood activities (4.14), FCS acts as a source of socio-economic development to small and marginal farmers(3.96), FCS helps to reduce the loss in farming operations (3.92) and FCS helps in rendering additional revenue through farming activities (3.61) exhibited a higher mean perception score. Whereas effective utilization of available resources of the farmer is highly possible through FCS was the least perceived. This implies that the tendencies for farmers to join cooperative societies are high. This confirms the findings of Bernard and David (2009) that processors and marketers join cooperative societies because of easy access to vital information.

Table 2: Perception in terms of usefulness and outcomes

S/no	Perception	Mean	Rank
1	FCS helped me to have better family livelihood Activities	4.14	1
2	Effective utilization of available resources of the farmer is highly possible through FCS	3.96	2
3	FCS helps to reduce the loss in farming operations	3.92	3
4	FCS helps in rendering additional revenue through farming activities	3.61	4
5	FCS acts as a source of socio-economic development to small & marginal farmers	3.44	5

Source: Field survey, 2018

GENERAL PERCEPTION

It is evident from Table 3 that the following five criteria indicated satisfactory level of perception viz., How do you feel after joining FCS (4.26), Are you interested to continue as a member of FCS (4.10), Did your FCS meet expectations (4.08), and FCS is useful to prepare myself for newer tasks and responsibility (3.52). Whereas FPO helped me in gaining general information and farming knowledge had indicated undecided level of perception with a mean score of 3.48. The findings agrees with Bernard and David (2009).

Table 3: General perception

S/no	General perception	Mean score	Rank
1	How do you feel after joining FPO	4.26	1
2	Are you interested to continue as a member of FPO	4.10	2
3	Did the FPO meet your expectations	4.08	3
4	FPO is useful to prepare myself to newer tasks &responsibility	3.52	4
5	FPO helped me in gaining general information & farming knowledge	3.48	5

Source: Field survey, 2018

CONCLUSIONS

Perception among the respondents ranked ‘good to excellent’. The perception on communication behaviour and group orientation indicated the extent of interaction among the members (3.83). Group members are actively participating in FCS meeting and other orientation programmes. Level of perception on usefulness and outcomes revealed that FCS helped members to have better family livelihood activities. The result indicated that after joining FCSs the members economic impact improved upsurge. FCS are playing major role by dissemination of information on recent technologies and new agricultural practices. The success of these farmers’ cooperative societies is very much dependent on the commitment of the members. The integrity and quality of leadership as well as suitable market environment are the most important factors for the successful growth of such farmer’s organizations. From the findings, farmers perceive FCS to be useful; it is therefore recommended that rural farmers be encouraged to identify with FCS around them for easy flow of ideas and information

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Determinants of adoption of information and communications technology (ICT)-based market information services by smallholder farmers and traders in Benue State, Nigeria

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ABSTRACT
Market access is increasingly relying on Information and communications technologies (ICTs) like telephony and internet that are only adopted haphazardly. Despite the need for ICTs in Market Information Services (MIS), ICT usage in Africa is low. Little is known about ICTs for use in MIS including, technology, its potential users and characteristics of both entities. The study examined ICT components used and factors influencing the adoption of the components used. Stratified random sampling was used to select respondents and data were collected from them using structured questionnaires. The data collected from 150 farmers and 50 traders were analysed using descriptive and influential statistics with the aid of STATA statistical package. Radio was the most used old ICT, whereas mobile phones were most used new ICT. Expensive handsets, poverty, poor power supply, lack of expertise and poor network coverage limited ICT use. Farmers with knowledge of ICT groups and those thinking that ICTs benefited agriculture were the more likely adopters of ICT-based MIS. Family size and land farmed influenced farmers' adoption, whereas age, trading experience, family size and monthly expenses influenced traders' adoption. Farmers and traders who majorly used ICTs for making profit were more likely to use mobile phone whereas those who stayed further from towns were less likely to use the component.

INTRODUCTION
Access to markets has been one of the major factors that have influenced smallholder agriculture in developing countries. Accessing markets allows smallholder farmers buy inputs and sell surplus of their subsistence and semi subsistence agriculture to enhance household incomes (Barrett, 2008). These markets can be between communities, villages, sub counties or countries. Markets that are often accessed by smallholder farmers who form majority of the poor in developing countries are characterized by poor infrastructure and limited investment capital (Barrett and Swallow, 2006). Market access helps alleviate poverty through commercializing agriculture and result in uniform distribution of incomes in developing countries (DCs).
Income distributions in DCs are biased by corruption tendencies which have hindered improvement in household welfare (Dao, 2008). Progress in household welfare is dependent on increments in productivity of household stocks of land, labour and capital through adoption

of better agricultural technologies that foster economic growth and alleviate poverty (Barrett and Moser, 2003). Even though important innovations continuously occur in many developing countries globally, Africa inclusive, new technologies are only adopted at a slow pace and haphazardly (Singh, 2006). The slow pace of new technological adoption has kept household incomes low.

However, increase in incomes would enable poor households save more financial resources and consequently gain required financial ability to invest in new technologies that are needed in commercial agriculture (Okello, 2005). Most developing countries like Nigeria are characterized by poor infrastructure in roads and poor administrative systems that are ethnic based and usually marginalize sections of poor farmers and traders, hence restricting smallholders' access to markets (Nwafor et al 2019).

ICTs are generally defined as a combination of activities that enhance capture, storage, processing, transmission and display of information by electronic means (Rao, 2004). These Information and Communication Technologies (ICTs) include cellular phones, internet/email, World Wide Web, Print media, and digital radio receivers. Sustainable information exchange in agricultural markets, technology and knowledge is becoming a critical area of agricultural development. Information exchange seems to be given limited priority and in agriculture the bulky load of agricultural information exchange between farmers and agricultural experts and advisors has been left to extension agents. The effectiveness and efficiency of these extension agents have been declining partly due to limited funding from support organizations like government and donor agencies, and the high costs required in maintaining and sustaining the physical movements of these agents between the rural areas where farmers are found, and the urban areas where agricultural experts are mostly stationed (Nwafor *et al.*, 2019).

Majority of factors affecting adoption of ICTs for MIS are generic in nature. For instance cost effectiveness and speed of information transfer, organizational characteristics like business size, system characteristics like availability and access to ICT services, and internal and external characteristics of the business household like education, past experience in using ICTs, attitude towards ICTs, business objectives and incomes among others (Windrum and Berranger, 2002; Dholakia and Kshetri, 2004). Galloway and Mochrie (2005) further opined that usage of ICTs by smallholder households that inhabit mainly rural areas is constrained by limited education and poor technological infrastructure.

With the current need of efficiency in understanding market price trends, accessing inputs and support services, farmers and traders need to use more efficient and appropriate new ICTs to take advantage of the existing opportunities. Timely access to market information, inputs and other necessary information services like weather changes, pest control techniques and others would increasingly enable small-scale farmers and traders make timely, reliable, realistic and economically viable decisions concerning what crops to grow, when to grow them, what products are for sale when and where, what inputs to use and how to use them. The main objective of this study was to assess the adoption of ICT-based market information services (MIS) by smallholder farmers and traders

MATERIALS AND METHODS

This study was conducted in Benue State, Nigeria. The state has a population of about 5,741,800 National Bureau of Statistics (NBS) (2016); its total land area is 34,059km^2 and it is the 11th largest land mass in the country. Benue State falls within longitude $7^0 47^1$, $10^0 0$E and latitude $6^0 25^1$, $8^0 8^1$N, the state shares boundaries with five other states in Nigeria. Benue State is divided into three senatorial districts, namely, North East senatorial district (Zone A) North

West Senatorial District (Zone B) and Benue South Senatorial district Zone (C). Stratified random sampling was used to select the respondents used for the study and data were collected from them using structured questionnaires. The data collected from 150 farmers and 50 traders across the three senatorial zones were analysed with descriptive and inferential statistics with the aid of STATA statistical package.

RESULTS AND DISCUSSION

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Table 1 presents a focus on some characteristics of the sample considering two broad sample strata; adopters and non-adopters. Means of education, experience in using ICTs, monthly income and distance to nearest town were statistically significantly different between adopters and non-adopters of ICT-based MIS. The class of households' monthly income, costs and distance covered to and from the nearest town were statistically different across groups

Table 1. Socio-economic characteristics of respondents (farmers and traders)

Mean values of farmers and traders						
		Farmers		Traders		
Variable	**Over all means (N=200)**	**Adopters (N=84)**	**Non adopters (N=66)**	**Adopters (N=40)**	**Non adopters (N=10)**	**F-test**
Experience	3.16 (3.81)	3.67 (4.35)	1.70 (3.15)	4.15 (3.17)	4.5 (2.7)	5.387***
Age	37.6 (11.4)	37.82 (12.12)	37.44 (11.87)	36.67 (9.47)	40.8 (7.9)	0.364
Education	6.52 (5.45)	6.68 (5.52)	5.71 (5.33)	8.08 (5.19)	4.3 (5.8)	2.184*
Income	75,322 (66,504)	72,428 (75,435)	62,705 (57,186)	103,916 (57,800)	68,516 (47,836)	3.467**
Family size	4.79 (3.34)	5.02 (3.32)	3.98 (2.74)	5.30 (4.05)	6.1 (3.3)	2.280*
Monthly costs	5,008 (6,019)	4,867 (6,772)	4,284.1 (6,780)	6,437.5 (2,678)	5,250 (1,296)	1.093
Distance	2.36 (1.05)	2.49 (1.00)	2.70 (0.96)	1.719 (1.04)	1.55 (0.59)	11.131***

*, **, ***Represents significance at 10, 5 and 1% levels, respectively,
Source: Survey data, 2020
The figures in parentheses are standard deviations

Logit model estimates of the determinants of traders' adoption of ICT-based MIS.
Logit model are presented in Table 7 and show that knowledge of existence of ICT groups perceived benefit of ICTs to agriculture and family size and land farmed in previous season significantly influenced adoption of ICTs for MIS by farmers. A one person increase in family size increased the probability of farmers to adopt ICTs for MIS by 60%.
Contrary to *a priori* expectations, an acre increase in land farmed previous season reduced probability to adopt ICTs for MIS for farmers by 15.3%. Farmers who had positive perception towards ICTs and those who had knowledge of existence of ICTs were more likely adopters than their counterparts. Though had a low participation in ICT usage (Table 1), women were more likely to likely to adopt ICTs for MIS than males. Table 8 presents Logit model results of factors influencing Traders' adoption of ICT-based MIS. Age of the trader, trading experience and monthly costs, family size, asset base, later age and better education

significantly influenced the probability of adopting ICTs for MIS by traders. A one person increase in the family size of traders' household increased the probability of adopting ICTs for MIS by 0.09%, as a one year increase in age and trading experience reduced such adoption by 0.08 and 0.03%, respectively. At later age, adoption of ICTs reduced more rapidly. A one shilling increase in monthly costs increased probability of ICT adoption by 0.18%.

Much of small-scale household farming in the study area was mostly practiced by women who had the primary responsibility of farming for household food security as mothers. Therefore males were less likely to devote to the use of ICTs in agricultural market information exchange. Having knowledge of ICT groups' existence availed farmers with an opportunity that attracted them to use and adopt ICTs for MIS. ICT groups were the sources of information and learning on how to use ICTs and benefits of ICTs, thus the positive influence is consistent with (Pickernell et al., 2004). ICTs enabled farmers to access general agricultural information like weather patterns, pests control, mobile money and others that were required in crucial decision making. That was consistent with Opata et al. (2011) and Peansupap and Walker (2005) who found positive perception towards ICTs being positively associated with expansion in ICT use.

Households mainly farmed for household food supply and mainly used rudimentary tools like hand hoes, knives and family labour. The average family size of farmers was small; below six persons (Table 3). Household average incomes were also very small and majority earned below 30 US $ per month (Table 3). Findings were consistent with Njuki et al. (2008) who found that large output proxied by large farm size in this research markets itself hence limiting need for market searches that were largely done using ICTs. However, Warren (2003) found that there was a positive association between farm size and ICT use. Increase in monthly costs on ICTs implied increased use and realisation of economic purpose of ICTs to traders hence traders' attraction to ICT-based MIS as costs increased. Whenever monthly costs increased, traders shifted to more efficient ICTs like mobile phones that gave them quick and more reliable information per unit cost, thus an increase in costs positively influenced adoption of ICTs. Nevertheless findings were contrary to *a priori* expectations and conclusions of Kovacic and Vukmirovic (2008) who found monthly costs to be negatively associated with the likelihood to use and adopt ICTs.

With more age and trading experience, traders mastered business patterns, the trends and tactics of the business environment, thus reduction in need and use of ICTs for MIS. +-Varying locations of family members necessitated more the need of communicating with each other using a more mobile device, thus increasing likelihood of using a mobile phone as compared to pay phone. Knowledge of ICT groups attracted households to gain membership to these groups in which they were more likely to be advised on using modern ICTs like mobile phones, thus a decreasing likelihood to use pay phone as compared to mobile phone. Having ICT groups' knowledge constituted a human capital and consequently a social asset as defined by (Parkinson and Ramirez, 2006). Increased experience in using ICTs enabled households acquire better skills and interest to use more complex ICTs like WWW and internet/email, consistent with Bailey (2009) who established that experience in using ICTs was positively associated with use of modern ICTs particularly the internet. With increasing incomes, households were less likely to use www, CD-ROM and internet/e-mail compared to mobile phone because these components were more capital intensive than mobile phones. Using internet or www required buying a computer and internet services.

Logit model estimates of the determinants of traders' adoption of ICT-based MIS.

Variable	Coefficient	Marginal effects
Family size	6.793 (3.105)**	0.00091

Age	-5.778 (2.499)**	-0.0008
Trading experience	-1.875 (0.809)**	-0.0003
Asset base	-3.803 (1.872)**	-0.0005
Ages	0.063 (0.027)**	0.00008
Education	0.102 (0.044)**	0.00001
Monthly cost	13.076 (5.558)**	0.00175
Constant	55.687 (39.126)	

**, significance at 10 and 5% levels,
Figures in parentheses are standard errors

Logit model estimates of determinants of farmers' adoption of ICT-based MIS.

Variable	Coefficient	Marginal effects
Gender	-2.058 (1.185)*	-0.409
Knowledge of ICT groups	2.318 (0.967)**	0.522
Thought if ICTs benefit agriculture	5.941 (1.395)***	0.872
Education of respondent	1.387 (1.115)	0.340
Monthly cost on ICTs	-0.268 (0.388)	-0.066
Family sizea	2.453 (0.715)***	0.602
Distance to nearest town centera	0.691 (0.748)	0.169
Land farmed previous season	-0.626 (0.278)**	-0.153
Constant	-7.213 (4.264)*	

; *, **, ***, significance at 10, 5 and 1% levels,
Figures in parentheses are standard errors

CONCLUSIONS

Mobile phone was one of the most important ICT components used by households to access market information services. Family size significantly and positively influenced ICT-based MIS adoption for both small-scale farmers and traders and having knowledge of ICT groups' existence availed farmers with an opportunity that attracted them to use and adopt ICTs for MIS. Therefore, innovation on ICTs should be stended to farmers via ICT groups and farmers organization

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Assessment of Deal-breaker traits and willingness to buy Preferred improved cassava seed by farmers in southern Nigeria

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ABSTRACT

To understand the varietal traits that attract cassava seed users and their willingness to buy the cassava varieties that possess the desired traits, a study was conducted in four selected states in southeast and south-south geopolitical zones of Nigeria where the activities of Building a Sustainable and Integrated Cassava Seed System (BASICS Project) is currently going on. The study adopted a combination of purposive and random sampling techniques to select 44 cassava farmers who have patronized the cassava seed entrepreneurs. Data obtained were subjected to descriptive statistics and probit regression analysis. Results of the study revealed three distinct trait categories that attracted the interest of the users. These categories include: Agronomic traits, product characteristics and marketability traits. Also, the probit regression output shows that farmers who planted local varieties previously were more likely to be willing to buy improved cassava varieties. Also, there is a varietal preference for TME 419 due to its high starch content and whitish colour including high dry matter content. It was therefore recommended that the identified traits should guide breeders in further varietal developments and the preferred variety (TME 419) should be massively multiplied and distributed to ensure that farmers have access to it at all times.

Key words: Cassava, seed, improved, varieties, farmer, preferred, trait

INTRODUCTION

Cassava is one of the important tropical root crops in Nigeria and Africa as a whole, considering that over 30 million Nigerian farmers, traders and processors are engaged in cassava value chains and agribusiness. Undoubtedly, Nigeria is the world's largest producers of the crop (FAO, 2020). Despite these achievements, cassava production is characterized by over 80% of smallholder farming outlay and dominant use of old and local varieties with traditional production technologies. These account for low yields experienced by the farmers.

National Root Crops Research Institute (NRCRI) Umudike and International Institute for Tropical Agriculture (IITA) Ibadan have developed varieties to meet the needs of the end users and increase demand. Such traits as high dry matter, high yielding, disease resistant, early maturing, high beta carotene content etc., constitute the quality demanded by the farmers.

However, quality content of these traits differs according to variety, therefore will form a major consideration for the farmer to buy such variety. Before now, Teeken et al (2018) had opined that Nigerian cassava breeding programs prioritize traits in setting breeding agenda so as to impact the largest possible number of people through improved varieties. Furthermore, IITA (2021) reported that improved cassava varieties have been subjected to years of preference studies with rural women who plant, process and eat cassava. These varieties resist pests like cassava mosaic disease (CMD), have the right color and texture when prepared as meals.

Willingness to buy certified improved cassava seed is a measure of the ability and preparedness of a farmer or user to exchange a commodity with money payment due to certain accepted criteria that the variety possesses. Certainly, for a farmer to be willing to pay for a preferred variety, his or her perception of the seed should be better than what the farmer is already using and have the ability to give a positive return on investment. The expectation is influenced by quality traits of the variety that meet the criteria for selection by the farmer and at an affordable price. Deal breaker traits are those attributes (phenotypical and genotypical) of a cassava variety that qualifies it for acceptability by the farmer and end users. Such traits include agronomic, processing and marketability qualities of the variety that distinguishes it from other varieties and thus attracts demand from users. In other words, deal breaker traits are those traits that the variety possess as a sufficient condition for a buyer to take decision to buy. This study therefore seeks to identify those traits that a cassava variety should possess that will facilitate farmers' preference and willingness to buy the variety.

METHODOLOGY

The study was carried out in south-east and south-south geopolitical zones of Nigeria. Two states were purposively selected from each zone based on BASICS activities in the states. In South-East, Abia and Imo states were selected while in South-South; Cross River and Akwa Ibom states were selected. The respondents were selected from a list of customers who purchased stems from the key CSEs that sold cassava seed during the 2018 planting season. A total of 44 cassava farmers who are customers to the CSEs were identified and selected. The researchers adopted a snowball method to trace the respondents whose distribution is presented in Table 1 below.

Table1: Distribution of respondents according to states

States	Number
Abia	7
AkwaIbom	20
Cross River	5
Imo	12
Total	44

Data collected were analysed using simple descriptive tools such as percentages and a probit regression analysis.

RESULTS AND DISCUSSION

Deal -Breaker Traits of Preferred Improved Cassava Varieties in the study area.

Preference to cassava varieties is pivotal to adoption, utility and commercialization of cassava. Since the varietal traits contained in the seeds cascades down through the product value chain from primary outputs (roots) to secondary products (*gari*, *fufu*, etc). These traits were characterised into three distinct groups based on farmers' responses as shown in Table 2 below.

They include the agronomic traits indicating cassava stems physical features at farm level which forms sources of attraction and a measure of farm level performance of plants amidst diverse climatic conditions. These certified improved cassava varieties show resilience to climate change, soil nutrient and water use efficiency especially during late season farming, they mature early, visibly show good stem architecture which is a good trait for cassava stem entrepreneurs, giving them more value for their labour, good root formation, shape and sizes are some of the best traits identified at farm level as quality agronomic traits.

In addition to this, the second classification of the deal breaker quality traits that leads to increased demand for product is product characteristics at processing level. These varieties show low water content during processing (a proxy for high dry matter), swelling property which is commonly referred to as less-for-better for commercial producers and households with large number of members. For a farmer who is also a processor, an important trait which these improved varieties are renowned for is underground storability. They have proven to have slow deterioration on the field which enables a farmer plan its product marketing regime and possibly take advantage of the off-peak market demand for cassava roots.

Finally, the market-level leading traits as identified from the survey include; brightness of product colour which is a leading property for marketing the product. Products of improved cassava varieties (*Gari*, *fufu*, *Abacha*) does not change colour under the sun or extreme conditions or over time. Its swelling property, draw ability of *gari* and *fufu* (a proxy for good starch content) is a market level leading trait of preference that meets consumer demands. Products of certified improved cassava varieties demonstrates visual and textural satisfaction for consumers and the popularization of these qualities leading traits are a yardstick for increased production and sales to attain maximum utility and overall consumer satisfaction. These findings justify previous findings (Bentley et al 2017, Bechoff, et al 2019).

Table 2. Deal -Breaker Traits of Preferred Improved Cassava Varieties in Southern Nigeria

Agronomic traits	Product characteristics	Marketability traits
High yield	Higher dry matter content	Bright colour of products (garri and fufu)
Early maturity	Considerable starch quantity	Swelling property of processed product
Soil nutrient-use-efficiency	Easy to process (Softens quickly) for fufu	Colour (yellow, Off-white)
Resilient to harsh weather and diseases	Yellow root	Very high demand market for product (stem and roots)
Excellent stem architecture	Underground storability of roots post maturity	Good starch quality for fufu (draw ability)
Good root size and formation	Good for garri processing	Products meet consumers visual and textural preference
Newness of product	Nutritional added advantage	Popularity of products in the area

Source: Field Survey, 2020

Willingness to buy certified improved cassava stem in South east and South-South Nigeria

The result of the probit regressions analysis presented in Table 3 reveals a pseudo-R squared value of 0.4148 and chi square value of 31.35 statistically significant at 1% level of probability indicating the goodness of fit of the regression equation. Three (3) out of the eleven (11) independent variables were statistically significant at different probability levels. These include planting of local varieties which had a direct relationship with willingness to buy the certified improved cassava varieties at 5% level of probability. This shows that majority of farmers who are willing to buy improved varieties are those who plant local varieties and are willing to try something new. Furthermore, purchase of variety TME 419 had a positive relationship with willingness to buy, statistically significant at 10% level of probability reflecting an increased demand for the variety. The more they purchase this variety, the higher their willingness to buy more. Those who had purchased TME 419 cassava varieties earlier are more willing to buy, having seen the performance of the cassava variety. This could be because the variety has become popular due to its deal-breaker traits that meets the diverse needs and preferences of different categories of consumers. Conversely, the variable purchase of TMS 01/1368 had an inverse relationship with willingness to pay at 10% level of probability. Which reflects a decline in willingness to purchase the cassava stems. This means that any farmer that purchased the variety will not be willing to pay for it any more, thereby confirming the position of Ayinde (2017) that adoption and consumption of bio-fortified pro vitamin A cassava varieties remain low in Nigeria. Also, in a related study, Onyeneke (2020) identified some constraints to adoption of bio-fortified cassava to include among others, quick root deterioration and high moisture content. These are poor processing qualities that may discourage purchase of seed of the yellow root variety.

Table. 3. Parameter estimates of the Probit regression on willingness to buy certified improved cassava stems in Southern Nigeria

Variables	Coefficient	Standard. Error	z-value
Constant	2.43	0.99	2.45**
Age	-0.32	0.25	-1.32
Use to buy seeds	-0.22	0.16	-1.36
Distance from farm	0.035	0.023	1.53
Planting of local varieties	1.040	0.49	2.11**
Price of seed (₦/bundle)	-0.00047	0.00053	-0.88
Area certified seeds (hectare)	-0.20	0.16	-1.27
Have income problem	-.073	0.20	-0.36
Purchased TME 419	0.99	0.59	1.67*
Purchased TMS 98/0581	-0.39	0.72	-0.54
Purchased TMS 98/0505	-1.09	0.70	-1.57
Purchased TMS 01/1368	-1.017	0.58	-1.77*
Number of obs	44		
LR chi2(3, 11)	31.35***		
Pseudo R^2	0.4148		
Log likelihood	-22.108291		

Source: Probit result computed from STATA14.0* is significant at 10%, ** significant at 5%

CONCLUSION

Deal breaker traits in a cassava variety plays an important role in determining the preference and willingness to buy such varieties. From the study, cassava varieties that possesses certain agronomic traits (high yielding, early maturing, soil nutrient -use efficiency, resilient to harsh weather and diseases, excellent stem architecture and good root size), product characteristics (high dry matter, considerable starch quality, easy to process (ferments quickly) for fufu, root colour, and nutritional added advantage) and marketable traits (bright colour, good swelling property, high market demand, good starch quality, good visual and textural quality and popularity of product in the area) are considered to possess deal breaker traits that determines the preferences and willingness to buy such varieties. The TME 419 variety is the most preferred variety. The probability of farmers to buy and continue to use TME 419 is significant whereas there is high probability for farmers who have used TMS 01/1368 to stop using it. It is therefore recommended that seed producers should increase the multiplication of TME 419 to meet its increasing demand.

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Professional Dissemination Pathways Used by Extension Agents to disseminate Climate Smart Practices among Rice Farmers in North Central, Nigeria

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ABSTRACT

The study determined the dissemination pathways used by the extension agents. Data was collected from a total of 88 extension agents in Kwara, Niger and Kogi States Agricultural Development Programme via the aid of questionnaire. The data were analyzed using descriptive statistics. The results showed that the mean age of the respondents was 48 years, predominantly male (95.5%) with average of 21 years of experience. The predominant dissemination methods used by the extension agents were farm and home visit ($\bar{x} = \mathbf{1.73}$), result demonstration ($\bar{x} = \mathbf{1.66}$), and method demonstration ($\bar{x} = \mathbf{1.58}$), slide shows ($\bar{x} = \mathbf{0.78}$) and films ($\bar{x} = \mathbf{0.68}$) are rarely used. The study hence recommends that that extension programme managers should understand these methods as the most effective method to disseminate information and provide them with necessary teaching materials. However in cases of large population the dissemination method that are rarely used might be effective, it therefore becomes pertinent that extension personnel are provided with this teaching aids and also trained on its usage.

Keywords: **Extension agents, Dissemination methods, Climate Smart Agriculture**

INTRODUCTION

In West Africa rice has been the region's primary source of calories since the early 1970s, and it is the third largest source of calories (after maize and cassava) (Haggblade, Longabaugh, Boughton, Dembele, Diallo, Staatz & Tschirley, 2012). As at 2016, rice produced locally in Nigeria was estimated at 4.8 million tons (FAO, 2016). According to (Udemezue, 2018), over 8 million tons of rice are consumed annually, with consumption increasing by roughly 6% per year, while a typical Nigerian consumes 24.8 kg of rice per year, according to (Anyaoha, Uba, Onotugoma, Mande, Gracen, & Ikenna, 2019). This implies that the consumption rate is far greater than the production rate.

Rice production faces numerous obstacles, the most significant of which is climate change, as most production activities are carried out in open fields. One of the researches conducted by (Anyaoha et al., 2019, Ronald, Dulle & Honesta, (2014)) pointed out that most rice farmers are faced with the challenges of change in rainfall pattern, pests and weed infestation, flooding which are all attribute of climate change. More so, most farmers lack the information and the resources needed to reduce the impact of climate change on rice production.

An innovation platform is one type of institutional innovation that can aid in climate change adaptation and mitigation (Leeuwis, Hall, Weperen & Preissing, 2013), and this platform is an area where both public and private extension agents can serve as a facilitator and a broker for a variety of tasks, such as bringing farmers together to discuss adoption techniques with researchers and building climate service tools.

However, research has revealed that farmers are responding to shifting climate situations, but the uptake of possibly advantageous measures known as climate smart agriculture is frequently low Arslan, McCarthy, Lipper, Asfaw, & Cattaneo, (2014) and McCarthy, Lipper, Branca, & Security, (2011). This was also ascertained by a number of researchers who have observed limited climate adaptation practices uptake and utilization (Akinnagbe & Irohibe, 2014; Ali & Erenstein, 2017; Tripathi & Mishra, 2017).

Climate Smart Agriculture (CSA) is an agricultural practice that aspires to raise production in a sustainable way, improve resilience (adaptation) wherever possible, reduce/eliminate GHGs (mitigation), and encourage the attainment of development goals and national food security (FAO, 2013). Examples include minimum or zero tillage, construction of water-retention structures, planting crops that enhance ground cover quickly and use minimal water), crop rotation and intercropping by incorporating legumes to promote soil fertility, farmyard composting and adopting farmyard manure management through biogas production, and minimize release of methane amongst others.

There are varieties of literatures as regard extension agents and climate change issues across countries (Oladele, 2011; Dimelu 2016; Kakota, 2017; Olorunfemi et al., 2019). These studies are useful because they assisted in informing us that extension agents have been involved in disseminating CSA practices to farmers. However, there is paucity of literature on the method the extension agents utilize in disseminating CSA practices to the farmers. It is on this note that this study attempt to identify the dissemination method used by the extension agents, so that they can be aware of the best teaching method they can use to disseminate information to farmers thereby increasing the adoption/ uptake of the CSA practice by farmer and thus ensure a sustainable increase of rice production in the study area.

The objectives of this study are to;

i. ascertain the socio economic characteristics of the extension agents in the study area.
ii. determine the information dissemination methods used by extension agents

METHODOLOGY

The study was carried out in the North Central zone of Nigeria. A multi-stage sampling procedure was used in selecting the respondents. The first stage involved a purposive Random selection of Kwara, Kogi and Niger States out of the seven states in North central, Nigeria due to the predominance of rice production in the states. The second stage involved a purposive selection of zone B out of four ADP strata in Kwara State, zone A out of three ADP strata in Niger State, and zone D out of four ADP strata in Kogi State, based on their involvement in rice production. The 3rd stage involve selection o the village extension agents, Zonal Extension Officers (ZEOs) and Block Extension Officers (BEOs) were interviewed totaling 88. This is because all the extension workers mentioned irrespective of their status were involved in disseminating CSA practice to the farmers and the total population selected was due to their small size. The data was analyzed with descriptive statistics.

RESULTS & DISCUSSIONS

The results in Table 1 show that the mean age of the respondents was 48 years, this is in line with (Olorunfemi et al., 2018). The mean number of farmers/ farm families per extension workers was 1936, which is in line with the findings of (Haruna, 2013). The mean years of experience is 21 years with majority been male (95.5%), married (95.5%), had tertiary education (85.2%) as the highest level of education and an average monthly income of ₦74,370.

Table 1: Socio-economic characteristics of extension agents

Characteristics	Mean ± Std deviation	Percentage (%)
Age (years)	48 ± 6.914	
Sex (male)		95.5
Marital status(married)		95.5
Years of experience	21 ± 9.38	
Level of education		85.2
Monthly income(naira)	74,370± 51,869	
Number of farm family/extension agents	1/1936± 6690	

Source: Field survey, 2020

The results in Table 2 present the teaching method used by extension agents in the study area. The table ranked; farm and home visits ($\bar{x} = 1.73$), result demonstration ($\bar{x} = 1.66$), methods demonstration ($\bar{x} = 1.58$), meetings at results demonstrations ($\bar{x} = 1.57$) as 1st, 2nd, 3rd and 4th teaching methods mostly used by the respondents in disseminating climate smart agricultural practices to the rice farmers. This implies that farmers in the study mostly have physical contacts with the extension agents, this could be because farmers prefer having direct contact with the extension agents and this may motivate them to adopt the CSA practices being disseminated to them. This is in consonance with the findings of Ahmed & Adisa, (2017) who reported that rice farmers in Kogi State perceived field demonstration and individual contact methods(result demonstration, farm & home visits) as the most effective teaching methods used by the extension agents. Khatam et al., 2013) stated that individual contact methods like farm visits, demonstration and home visits are the major methods used by extension agents for the farmers. Likewise Abdulshakur, Yusuf, Nnaji, & Haruna, (2020) ranked group discussion and demonstration 1st and 2nd as the most effective methods used by extension agents.

The table further reveals the teaching methods rarely used by the extension agents include: films ($\bar{x} = 0.68$), personal letter ($\bar{x} = 0.78$), slide shows ($\bar{x} = 0.78$), flip charts ($\bar{x} = 0.82$), radio ($\bar{x} = 0.85$), drama ($\bar{x} = 0.85$) and circular letters ($\bar{x} = 0.86$). This could be due to high cost of disseminating information through these media or due to lack of competence in usage of the teaching aids.

Table 2: Distribution of Respondents by teaching/Dissemination methods used

Dissemination methods	Often used Freq (%)	Rarely used Freq (%)	Never used Freq (%)	Mean	Std. Deviation	Rank

a.	**Individual contact methods**						
	Farm and home visits	64(72.7)	24(27.3)	0(0)	1.73	.448	1st
	Telephone Calls	40(45.5)	41(46.6)	7(8.0)	1.38	.631	
	Office calls	38(43.2)	41(46.6)	9(10.2)	1.33	.656	
	Personal letter	14(15.9)	41(46.6)	33(37.5)	.78	.702	
b.	**Group Contact methods**						
	Result demonstrations	61(69.3)	24(27.3)	3(3.4)	1.66	.544	2nd
	Method demonstration	55(62.5)	29(33.0)	4(4.5)	1.58	.582	3rd
	Meetings at result demonstrations	54(61.4)	30(34.1)	4(4.5)	1.57	.583	4th
	Lecturer meetings	24(27.3)	57(64.8)	7(8.0)	1.19	.564	
	Conferences	12(13.6)	66(75.0)	10(11.4)	1.02	.502	
	Leader training meetings	45(51.1)	40(45.5)	3(3.4)	1.48	.567	
	Discussion meetings	41(46.6)	41(46.6)	6(6.8)	1.40	.617	
	Tours (field trips)	27(30.7)	50(56.6)	11(12.5)	1.18	.635	
	Schools	9(10.2)	44(50.0)	35(39.8)	.70	.646	
	Flip chart	11(12.5)	50(56.8)	27(30.7)	.82	.635	
c.	**Mass Contact methods**						
	Posters	51(58.0)	30(34.1)	7(8.0)	1.50	.643	5th
	New Stories	25(28.4)	41(46.6)	22(25.0)	1.03	.734	
	Circular letters	21(23.9)	34(38.6)	33(37.5)	.86	.776	
	Radio	15(17.0)	45(51.1)	28(31.8)	.85	.687	
	Television	28(31.8)	32(36.4)	28(31.8)	1.00	.802	
	Exhibits	24(27.3)	52(59.1)	12(13.6)	1.14	.628	
	Leaflets	28(31.8)	41(46.6)	19(21.6)	1.10	.728	
	Bulletin	29(33.0)	33(37.5)	26(29.5)	1.03	.794	
	Campaign	22(25.0)	39(44.3)	27(30.7)	.94	.748	
	News paper	11(12.5)	38(43.2)	39(44.3)	.68	.687	
	Extension journals	38(43.2)	37(42.0)	13(14.8)	1.28	.710	
	Newsletter	22(25.0)	40(45.5)	26(29.5)	.95	.741	
	Pamphlet	27(30.7)	43(48.9)	18(20.5)	1.10	.712	
	Folders	21(23.9)	45(51.1)	22(25.0)	.99	.703	
	Drama	16(18.2)	43(48.9)	29(33.0)	.85	.704	

Source: Field Survey, 2020

CONCLUSION AND RECOMMENDATION

The predominant dissemination pathway/ method used by the extension agents were: farm and home visits, result demonstration methods, demonstration meetings at results demonstrations while, dissemination pathway/ method rarely used by the extension agents include: films personal letter, slide shows, flip charts, radio, drama, and circular letters. It is recommended that extension programme managers and those concern with agricultural development understand these method as the most effective method to disseminate information and provide them with necessary teaching materials however in cases of large population the dissemination method that are rarely used might be effective, it therefore becomes essential that extension personnel are provided with this teaching aids and also trained on its usage.

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Climate Change Issues in Nigeria: A Call For A Sustainable Policy in Agricultural Sector

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ABSTRACT
Climate change has been reported to have been caused by human activities and its impacts on global economy and the citizen is devastating in nature. This paper aims to identify various ways through which farmers in the rural community contribute to climate change. This study intends to contribute to environmental sustainability and farmers' adoption of cleaner agricultural production practices. This research adopted descriptive survey design type. The methodology includes the use of four stage sampling procedure to select 120 farmers from the study area. Interviewed schedule was used to collect data from the respondents, while the data collected were analyzed using descriptive statistics. The findings revealed that majority (92.4%) engaged in bush burning, 96.7% were involved in deforestation,59 % engaged in soil nutrient depletion activitieswhile 92.4% engaged in drainage construction. All these activities contribute to global warming. Therefore, it is recommended that awareness campaign about the cause of climate change should be organized for the farmers in the zone,while policy should be formulated to encourage farmers to use climate smart agriculture in their production process in order to establish environmental sustainability.

Key words: Climate change. Bush burning, Deforestation, Sustainability, Farmers activities Global warming

INTRODUCTION
Climate change is a global issue of concern that puts every nation under pressure to prevent the consequences and the risk through policy making and implementation (United Nations Climate Change Secretariat, [UNCCS], 2019). This unfortunate incidence calls for action in all ramification because neglecting the danger and negative effects of this monster call "climate change" will put the world in jeopardy (International Panel of Climate Change [IPCC],2018). The world is facing a trying time of nature as temperature increases with unpleasant consequences that ravage many sectors of the economy: agriculture, health, social, manufacturing and economic sectors(Nelson, 2009; Oppenheimer *et al.*, 2014; Elum *et al.*, 2017;,Obaniyi*et al.*, 2019, Ugwoke, *et al.*, 2020; Fawzy *et al.*, 2020). Researches in the past have identified major contributors to global warming such as : Natural systems which include forest fires, earthquakes, oceans, permafrost, wetlands, mud volcanoes and volcanoes (Fuss et al,,. 2018:Yue and Gao 2018), but few research focuses on farmers' activities that lead to climate change and that is the area this research paper covered. It is against this background that this research seek to identify the contributions of human beings mostly farmers who

engaged with nature on daily basis. Therefore, the main objective of this study was to assess the farming activities that contribute to climate change in order to provide advisory service in mitigating effect of climate change in the zone.

MATERIALS AND METHODS

The study was carried out in Ekiti State, Nigeria which is located between longitudes 4°5′ and 5°45′ east of the greenwich meridian and latitudes 7°15′ and 8° 5′north of the equator. It lies south of Kwara and Kogi States, east of Osun State and bounded by Ondo State in the west and south. By the 2006 census, the population of Ekiti State was 2,384,212. Ekiti is an upland zone rising over 250 metres above sea level. The total land area is 6,353 km^2 (2,453 sq mi) and ranked 31st of 36 states of Nigeria . It has rhythmically undulating surface and also consist of dome rocks. The State experiences climate of two distinct seasons. These are the rainy season (April – October) and dry season (November – March). Temperature ranges between 21° and 28°c with high humidity. Tropical forest exists in the south, while guinea savanna predominates in the north. The predominant ethnic group in the study areas is Yoruba.

This research adopted descriptive survey type. It involves the use of four-multistage sampling techniques. The population of the study consists of 16 LGAs,out of which 8 LGAs were randomly selected. Two wards were selected from each LGAs. Three villages were selected from each ward, while forty cocoa farmers were selected randomly from each village to give a sample size of 120 farmers. The data on the activities of farmers that contributed to climate change were collected from the respondent using structured questionnaire on how and extent at which the farmers participated in those activities. The categories include Never, Once, Occasionally, Often and All the time ’.

Data Analysis

The data collected was analyzed using descriptive statistics Data collected were coded into a software Statistical Package for social sciences (SPSS version 23) was used after coding, the variable were measured at ordinal level before processing.

RESULTS AND DISCUSSIONS

The involvement of respondents in the activities that contribute to climate change

Involvement in Bush Burning Activities

Bush burning is one of the activities that contributed to climate change through the release of Green House Gases as more carbon is being released into the atmosphere thereby causing global warming(Ritan, 2013; Yue & Gao 2018; Fawzy*et al*., 2020). Also, the smoke from the bush burning can result to a great health challenge for farmers. The results (Table 1) show that majority (84.2%) had occasionally or once burned bush when preparing the land for cultivation while few (9%) still engaged in the habit of burning bushes often and all the time. This call for quick action by the orientation agency and extension agents to campaign against subsequent bush burning as more carbon which result to global warming are being released. Farmers should be taught about the importance of keeping their atmosphere save.

Involvement in Deforestation Activities

Deforestation is a deliberate attempt of cutting tree down in the forest in order to establish cocoa farms and build farm houses. This is one of the major factors that contribute to climate change (Ruddiman, 2003, 2005; Olagunju, 2015; Yue & Gao, 2018; Fawzy *et al.*, 2020) The result (Table 1) shows that 94 % of the respondents engaged in deforestation as following (47.5% cut tree once, 18.3% occasionally, while 29.2% often engaged in cutting tree .on their farm for agricultural purpose. According to FAO (2005), *Nigeria* was ranked the highest*in* terms of the rate of deforestation which result to climate change.This call for quick action by the orientation agency and extension agents to campaign against subsequent cutting of tree as more carbon which result to global warming are being released. Cocoa tree also help to store carbon therefore farmers should be paid compensation from ecological fund for keeping our world.

Involvement in removing dry leaves from the topsoil

The act of parking leaves on the farm is done by some small-scale farmers in order to prevent bush burning disaster as they believe that this will prevent the farm from burning. The results (Table 1) show that 59% carried out the sweeping of the farm during dry season while 41% never engaged in sweeping dry leaves from the land cover of their farms. The implication of removing dry leaves from the topsoil is that it opens the land for erosion and loss of soil nutrient as the organic matter content is reduced. This action calls for extension agent interventions by informing the farmers about the danger of removing dry leaves from their topsoil.

Involvement in constructing drainage to control flood and erosion on their farm

The devastating effects of flood caused by excessive rainfall as a result of unpredictable climatic condition which may have caused rivers to overflow their boundary, and subsequently result into soil degradation and losses to farmers have been documented (Yue & Gao, 2018) . This has been reported to be a major challenge to food security (Ritan, 2013). The results (Table 1) show that majority (93.3%) involved in constructing drainage system in their farm to control excess flooding activities. This will help to safeguard against flood and consequently promoting food security and a peaceful ecosystem. Orientation agency should therefore encourage farmers in the other states to imbibe what Ekiti State farmers have endorsed.

CONCLUSION AND RECOMMENDATIONS

The study concludes that the farmers activities that contributes to climate change in the study area were involvement in bush burning deforestation activities which involve cutting down of trees in the forest in order to establish their farms, the removal of dry leaves from the top soil and Involvement in constructing drainage to control flood and erosion on their farms. The result shows that majority carried out these activities and this is detrimental to the nutrient availability of the soil and consequence low yield from the farms. Therefore, it is recommended that awareness campaign against these practices must be embarked upon and speedy afforestation programme must be established in order to improve carbon sequestration level and consequently reduce Green House Gas (GHGs) emission in the area, thereby reducing the impacts of the climate change in Sub Sahara Africa as a whole. Moreover, Climate smart agriculture should be introduced to farmers to improve their vulnerability level and enhance their economic status. For instance, the used of drought resistant varieties, irrigation technology, weather forecast update and insurance cover can be introduced to farmers.

Table 1: Showing different levels of involvement in activities that contribute to climate change

LEVEL OF INVOLVEMENT	BUSH BURNING F, (%)	DEFORESTATION F, (%)	DRY LEAVES REMOVAL F, (%)	DRAINAGE CONSTRUCTION F, (%)
NEVER	8 (7.6%)	4 (3.3%)	49 (40.8%)	8 (7.6%)
ONCE	15 (12.5%)	57 (47.5%)	14 (11.7%)	44 (36.7%)
OCCASIONALLY	86 (71.7%)	22 (18.3%)	48 (40.0%)	48 (40%)
OFTEN	9 (7.5%)	35 (29.2%)	9 (7.5%)	18 (15%)
ALL THE TIME	2 (1.7%)	2 (1.7%)	0 (0%)	2 (1.7%)
Total	120 (100%)	120 (100%)	120 (100%)	120 (100%)

Source: Field Survey, 2018

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Agricultural Extension Integrated Approach Model (AEIAM) in reducing Covid-19

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ABSTRACT

This study aims to examine the devastating effects of the Covid-19 pandemic among the human and animals in Nigeria and to proffer a way out of this national attacks through Covid -19 Agricultural Extension Integrated Approach Model (CAEIAM). The recent pandemic has contributed to the downfall of many nations; therefore, there is a need to diversify our resources in fighting this plaque. The truth is that whatever thing that has affected the health status of the production sectors of the economy, has successfully reduce the welfare of the household communities. Agricultural extension is concerned with improving the welfare of the nations through dissemination of new technologies; improvement of crop and animal production system thereby improving their livelihood. Nigeria as one of the developing countries must wake up to the fact that Covid -19 vulnerability can be reduced with integrated approach system known as Covid -19 Agricultural Extension Integrated Approach Model (CAEIAM). Therefore, application of the multifaceted approach which include proper diet, application of faith and supernatural intervention together with strict adherence to Covid-19 Protocols will go a long way in reducing the spread and the impact of Covid-19.

Keywords: Agricultural Extension, COVID-19 pandemic, Integrated approach, Immune system, Model

INTRODUCTION

Covid is a colossal gathering of diseases that may cause infirmity in animals or individuals. (WHO, 2019) to activate respiratory defilements going from the standard infection to more genuine contaminations, for instance, Middle East Respiratory Syndrome (MERS) additionally, Severe Acute Respiratory Syndrome (SARS). This new infection and contamination were anonymous before the flare-up started in Wuhan, China, in December 2019 (World Health Organization [WHO], 2020). A conclusion with Covid 229E, NL63, OC43, or HKU1 isn't equivalent to a COVID-19 finding. Patients with COVID-19 will be evaluated and dealing with uniquely in contrast to patients with customary Covid analysis (WHO, 2019). There is by and by no considerable verification that any food or dietary example can help our safe framework and maintain a strategic distance from or treat COVID-19, anyway helpless sustenance brings about extended contaminations moderate repairing from injury and diseasesand builds weakness to signs and confusions from resistant framework brokenness. The resistant framework is responsible for fighting unfamiliar trespassers in the body, as pathogenic microscopic organisms and infections, and furthermore ends cells inside the body when they become harmful.

Theoretical Framework

A decent nourishment will guarantee a strong invulnerable framework that can help any assault by the infection. Since there is by and by no proof that any enhancement or food can assist our insusceptible framework with treating or forestall viral contaminations aside from Vitamin C. A legitimate eating regimen can likewise assist with guaranteeing that the body is in the most grounded conceivable state to fight and forestall the infection. Nutrient C is significant for keeping a solid insusceptible framework, it is water dissolvable a sign that it can't be put away by the body, this implies you need to supplant it every day by burning-through nutrient C rich fruits(apple, guava, banana, apple, melon, straw berry, pineapple, grapefruit, orange, papaya, blackcurrant, Longman natural product, wallop) including a serving of vegetables(lentils, beans, green ringer peppers, ginger, garlic, lime, kale, coriander (dried), broccoli, green ,stew pepper). It bolsters a decrease in the time allotment and seriousness of indications related with upper respiratory viral diseases, advances phagocytic cell capacities, and backing sound T-cell work, gives cancer prevention agent action to help mending at locales of irritation. The everyday suggested dietary recompense for Vitamin C is 90mg/d for men and 75mg/d for ladies.

This study hereby proposes this framework and model in reducing the impacts of Covid- 19. This is referred to as Covid -19 Integrated Approach.Model(CAEIAM).

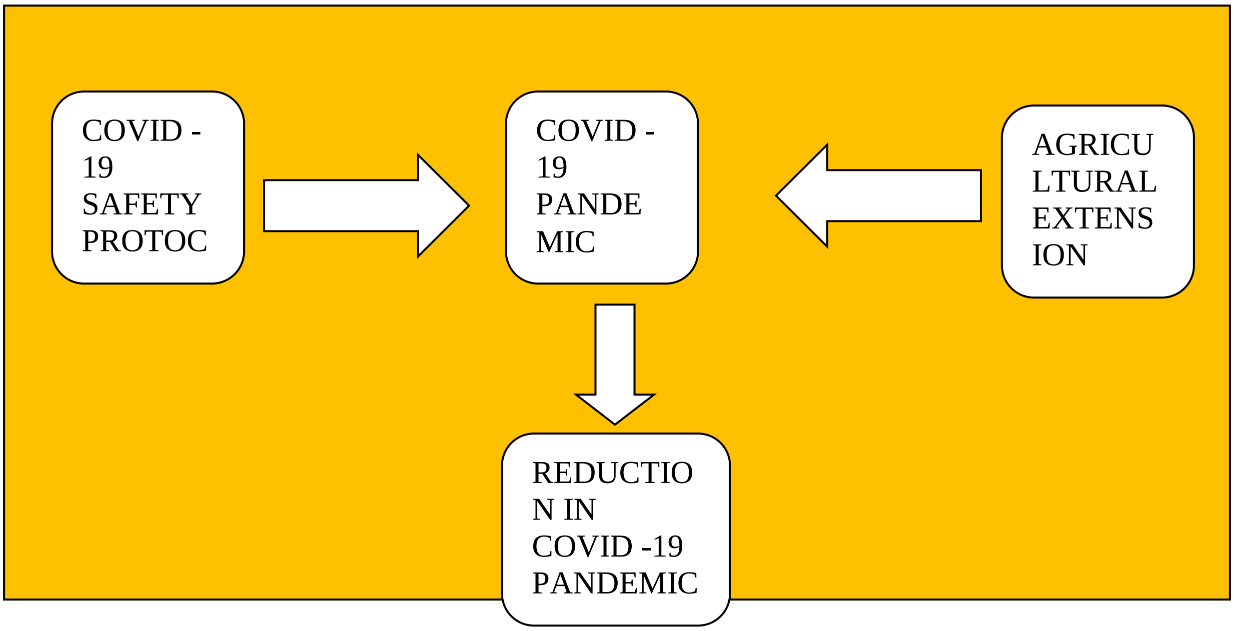

Fig 1: Covid -19 Agricultural Extension Integrated Approach Model (CAEIAM).

Source: Authors' Compilation:

MATERIALS AND METHODS

This study used desk research method and logical thinking to examine the devastating effects of the Covid-19 pandemic among the human and animals in Nigeria and to proffer a way out of this national attacks.The study area is Nigeria, but the research used the past works of authors which are not limited in scope as it covered different research from different authors. This research adopts writing audit method in gathering information .Writing audits can take two significant structures. The most common one is the "writing survey" or "foundation" segment inside a diary paper or a part in an alumni theory. This segment orchestrates the surviving writing and more often than not distinguishes the holes in information that the observational investigation addresses (Sylvester, Tate, and Johnstone, 2013). It might likewise give a hypothetical establishment to the proposed investigation, substantiate the nearness of the examination issue, legitimize the exploration as one that contributes something new to the cumulated learning, or approve the techniques and methodologies for the proposed investigation. The second type of writing audit, which is the focal point of this part, establishes a unique and significant work of research all by itself (Paré, Trudel, Jaana, &,Kitsiou, 2015). This research reviewed different area of intervention by government in reducing risks associated with Covid-19 pandemic and therefore proposes an Integrated Agricultural Extension Model as a way of reducing the impact of Covid-19 .

RESULTS AND DISCUSSION

In the current circumstance, COVID-19 has constrained a novel arrangement of difficulties for the person to keep a sound eating routine. The state of lockdown, social separating and self-segregation are critical measures to fixing the twist of the sickness, despite the way that these measures have extraordinary repercussions on a group life. The demonstration of limitation to one's home affects the well – being of an individual, remembering changes for eating designs, resting propensities, and actual development. It would empower latent practices that impact mental and actual prosperity and lead to an extended peril of heftiness (Khaled and Benajiba, 2020). Dread and strain may likewise cause changes in dietary works on prompting unfortunate dietary examples and less longing to eat or with joy during eating as per (Chen et al., 2020).

Zinc is additionally urgent for the normal turn of events and working of our resistance cells and antibodies. It is ideal to get zinc from food sources as enhancements can meddle with the retention of different supplements like iron and copper. It is essential to keep up satisfactory however not in over-the-top level, overabundance utilization of zinc has additionally shown negative impacts on resistant capacity and can restrain the phagocytic cells. Phenomenal wellsprings of zinc incorporate Spinach, Asparagus, sesame seeds, pumkin seeds, Garbanzo beans, Lentils, cashews, quinoa. Studies have uncovered that absence of top-notch protein can bring about consumption of invulnerable cells, absence of capacity of the body to make antibodies, and other safe related issues. Top caliber, complete proteins are found from numerous sources: eggs, fish, and shellfish, tofu, tempeh and quinoa, numerous vegetables and grains are likewise incredible wellsprings of a significant number of the invulnerable animating amino acids, earthy colored rice, broccoli, mushrooms, nut margarines, seeds and nuts. (Aman, & Masood, 2020)

Keep your liquid admission up, absence of liquid in the body can cause weariness, exasperate cold and influenza indications and hinder your processing, the proposed measure of liquid you ought to drink is around 2 liters each day and this should come essentially from water. Tips for expanding liquid admission include: Make a propensity for continually beginning the day with a glass of water when you awaken. Your body dries out for the time being and needs liquid for rehydration ; Try warm water with a cut of lemon for the duration of the day for a warming method to build your liquid admission ; and Try natural teas like peppermint, jasmine or lemon and ginger teas which are all caffeine free((Aman, & Masood, 2020)

Successive hand washing is essential to secure against Coronavirus, colds and different microscopic organisms that cause ailment. These microorganisms and infections can be available on the surfaces that we contact, while we are outside or inside, the washing of hand is vital to forestall reaching the infection.

Roles of Agricultural Extension and Rural Advisory Services in combating COVID-19

The recent pandemic has contributed to the downfall of many nations; therefore, there is a need to diversify our resources in fighting this plaque. The truth is that whatever thing that has affected the health status of the production sectors of the economy, has successfully reduce the welfare of the household communities. Agricultural extension is concerned with improving the welfare of the nations through dissemination of new technologies; improvement of crop and animal production system thereby improving their livelihood. Nigeria as one of the developing countries must wake up to the fact that Covid 19 vulnerability can be reduced with increase in the food quality taken by the rural and urban populace. Therefore, there is a need to diversify our efforts as a nation to the production of fruits and vegetables that is rich in vitamin c and zinc. Farmers should be trained on the improved practices that will guarantee large production while input should be supplied by the government through research institute such as National Horticultural Research Institute NIHORT, etc. On that note,the future role of agricultural extension and rural advisory services in combating covid-19 include the dissemination of the new technology to the farmers and rural dwellers on the reality of Covid -19. Moreover, the sensitization of rural populace about the prevention protocol of social distance, washing of hands, using of sanitizer, using of Nose Mask, participating in Covid-19 vaccination, and application of religious belief and faith system in reducing the effects of Covid -19 on human being system and ways of lives. Above all, organization of training on the crops and animal production technologies is also fundamental role of extension agents.

CONCLUSION AND RECOMMENDATIONS

In conclusion, this paper call for paradigm shift in our approach to arrest Covid-19 pandemic through changes in our believe system. This paper suggests multifaceted approach which include social distancing, washing of hands, using of sanitizer, Covid-19 vaccine, and application of religious belief and faith system in reducing the effects of Covid -19 on human being system and ways of lives.

Faith and believe system of people have been proved to have tremendous impact on their health, therefore Nigeria and other countries of the world must not shy away from the fact that Covid -19 can be healed supernaturally by the hand of God and indigenously through herbs etc. Therefore, let people have freedom of practicing what they believe in order to be free from this plaque. Churches and Mosque should be opened for people to worship their God in order to gain emotional power to live. There should not be banned on social gathering but rather be moderated.

Above all, building the immune system of people who lived in both the rural and urban area should be our major concerns and that is why the services of agricultural extension personnel should be employed in training the farmers or producers in the best methods of producing vegetables and fruits which will help in this regards. Finally, there should be collaboration between the health workers and agricultural extension professional on the necessary information on the nutrient required in building our immune system.

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Perceptions of the respondent on consumption of fruits and vegetables as a way of reducing COVID-19 Pandemic

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ABSTRACT

Covid-19 is a twenty-century pandemic that has destroyed many sectors of the economy. Therefore, there is a need to identify several ways of eliminating these global challenges. This study aims to assess the various strategies of reducing the spread of Covid-!9 in Nigeria and in the world. The research method used in this study was quantitative research, while the design type was a survey type. Survey questionnaires were sent out randomly to a specific population of people who are in tertiary institution (Landmark University). The purposive and random sampling technique were adopted. The data collected were analyzed using descriptive statistics. The results show that the majority of the respondents were males (65%) , 40% of the respondents were Master Degree holder (M.Sc.),while 35% with their (Ph.D.) The mean age of the respondent was 39 years, while 82% were salary earners . The result further shows that 82.5% agreed that the consumption of fruits and vegetables serve as a way of boosting immune system against COVID-19.The findings also revealed that 65% of the respondents consumed fruits and vegetables regularly specifically (42.5%) of the respondents also consumed ginger, onion, garlic and turmeric every day. The finding also revealed the COVID-19 pandemic precautionary measures practiced by the respondents in the study area: It was revealed that of 80% of the respondents practiced social distancing, use of face masks, use of hand sanitizer and combination of scientific guideline and indigenous knowledge while 75% practiced good hygiene, consume ginger and garlic, hydroxyl chloroquin and were holding prayer meetings as precautionary measure because they believed their God is a God of protection and can protect them.

This study concludes that the consumption of fruits and vegetables, personal hygiene, prayer to God as well as following precautionary measures are diverse strategies of reducing the spread of COVID-19. Therefore, this study recommends an integrated approach to solving covid-19 pandemic.

Keywords: Nutrition, Fruits and vegetables, Immunity, COVID-19 pandemic, integrated approach

INTRODUCTION

Coronavirus pandemic is at present a main test across the globe (World Health Organization [WHO],2022). This pandemic has caused a lot of damage which has contributed to food insecurity, poverty and economy melt down across the globe (WHO,2022;Schmidhuber, 2020;High Level Panel of Experts [HLPE],2020b). The general view of using vaccination as a preventive measure has been accepted by the European countries. However, Africa is a unique continent with diverse view to the cure and prevention of Covid- 19. In Africa, there is a divergent view to the cure of the pandemic. Some people believe that using herbs can cure Covid, while some people believe that prayer to supreme being (God) can cure Covid-19 (Silveira, 2020 There are much evidence of supernatural healing based on believe and faith of an individual. Another school of thought believed that the effects of Covid -19can be reduced with good diet. It is Important to achieve and keep up with great healthful status to support safe framework that can battle against infection. Wholesome status of individual is impacted by a few factors, for example, our believe, wellbeing status, way of life, what we consume(HLPE.,2020b). Feeble Immune framework, utilization design and healthful status of people have been utilized as strength towards disarray during this COVID-19 pandemic (Aslam , Majeed , Aslam,& Irfan , 2017.On that note, this study aims to assess diverse strategies in reducing the spread of Corona virus in Nigeria. This research therefore examines the view of academicians about the consumption of fruits and vegetables in boosting our immune system.

METHODOLOGY

The study was carried out in Landmark University metropolis. Landmark University is a private owned institution. The University is located at Km 4 Ipetu, Omu-Aran Road PMB 1001, Omu-Aran, Kwara State. (43FP+3V8, Road, 251103, Omu-Aran). Landmark University consist of Four(4) Colleges with over 3,000 students and lecturers and staff who are of different status and academic qualifications and gender. The research method used in this study was quantitative research, while the design type was a survey type. Survey questionnaires was sent out randomly through Google form to a specific population of people who are in tertiary institution (Landmark University). The purposive sampling and random sampling technique were adopted. The data collected were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

The results presented in Table 1 show some of the socio-economic characteristics of respondents selected for the study. The table reveals that more than half (65%) of the respondents were males, while 35% were females, the figure implies that more males work in Landmark University either as a non-academic or academic staff. In terms of age, less than half (37.5%) of the respondents were within the ages of 35-44 years, while 30% were of the ages between 25 and 34years and 22.5% were between the ages of 45 and 54 and 2.5% were between the ages of 55-64 and 65-74 respectively. The mean age was 39.1 years. This is an indication that majority of the respondents were in their active age.In terms of educational status, 40% of the respondent are Master Degree holder (M.Sc.),while 35% with their (Ph.D.) and 25% with only their first Degree. This implies that a large proportion of the respondents had acquired second degree certificate and shows that they are well educated and could follow the COVID-19 pandemic precautionary measures and boost their immune system as education is vital to get informed about the pandemic.

Table 1: The Socio-economic characteristics of the respondents

Gender	Frequency	Percentage (%)
Male	26	65.0
Female	14	35.0
Total	**40**	**100.0**
Age		

18-24	2	5
25-34	12	30
35-44	15	37.5
45-54	9	22.5
55-64	1	2.5
65-74	1	2.5
75-84	0	0
Total	**40**	**100.0**
Educational Status		
Primary	0	0
Secondary School	0	0
OND/HND	0	0
University Degree	10	25.0
Post graduate (M.Sc.)	16	40.0
Post graduate (Ph.D.)	14	35.0
Total	**40**	**100.0**
Occupational Status		
Self Employed	5	12.5
Salary Earners	33	82.5
Students	2	5.0
Unemployed	0	0
Total	**40**	**100.0**

Source: Field Survey, 2021

Table 2 reveals the perceptions of respondents on the consumption of fruits and vegetables in boosting immune system against COVID-19 pandemic. The results show that more than three-quarter(82.5%) of the respondents agreed that consumption of fruits and vegetables can be used to boost immune system against covid-19. This perception may be as a result of their knowledge about the importance of fruits and vegetables to human health. The finding also reveals that 15% of the respondents were undecided. This implies that they could not really say if the consuming fruits and vegetables could boost immune system to fight against covid-19 pandemic, while a few (2.5%) disagreed. The table also reveals the proportion of respondents that consume fruits and vegetables as an antibody against COVID-19 in which 65% were taking fruits and vegetables regularly whereas 35% were not taking fruits and vegetables. This is an indication that there is heavy consumption of fruits and vegetables to boost immune system against covid-19 in the study area. However, majority (42.5%) of the respondents also consumed ginger, onion, garlic and turmeric every day, 27.5% consumed ginger, onion, garlic and turmeric four times in a week, 22.5% consumed ginger, onion, garlic and turmeric once in a week, 5% consumed ginger, onion, garlic and turmeric once in two weeks and few (2.5%) of the respondents consumed ginger, onion, garlic and turmeric once in a month.

Table 2: Perceptions of the respondents on consumption of fruits and vegetables can boost immune system against COVID-19

Fruits and vegetables can boost immune system against COVID-19	**Frequency**	**Percentage**
Strongly agree	11	27.5
Agree	22	55.0
Undecided	6	15.0
Disagree	1	2.50
Total	**40**	**100.0**
Do you take Fruits And Vegetable regularly		
Yes	26	65.0
No	14	35.0
Total	**40**	**100.0**
How often do you take spices such as ginger, onion, garlic and turmeric		
Everyday	17	42.50
Four times in a week	11	27.50
Once in a week	9	22.50
Once in two weeks	2	5.0
Once in a month	1	2.50
Total	**40**	**100.0**

Source: Field Survey, 2021

Table 3 shows COVID-19 pandemic precautionary measures practiced by the respondents in the study area. It was revealed that each of 80% of the respondents practiced social distancing, use of face masks, use of hand sanitizer and combination of scientific guideline and indigenous knowledge. The World Health Organization (WHO, 2020a) reported that masks can help prevent the spread of covid-19 from the person wearing the mask to others The result also revealed that each of 75% practiced good hygiene, consume ginger and garlic, hydroxychloroquin and were holding prayer meetings as precautionary measure because they believed their God is a God of protection and can protect them, 62% regularly disinfect contact surfaces such as door handles, furniture etc.50% embraced technology and internet so as to reduce the need for unnecessary movements and small portion (25%) of the respondents believed that apps can be created to make easy the delivery of market and perishable products to people's homes. This result revealed that majority of the respondents were aware and practicing the precautionary measures to prevent COVID-19 pandemic in the study area.

Table 3:COVID-19 pandemic precautionary measures practiced

Idea on how Covid-19 impacts can be reduced in our society	**Frequency**	**Percentages (%)**
Social distancing	32	80
Use of face masks	32	80
Use of hand sanitizers	32	80
High level of personal responsibility		
Good hygiene	30	75
Regular disinfection of contact surfaces such door handles, furniture	25	62
regular consumption of ginger and garlic, hydroxychloroquine	30	75

Embrace technology and internet so as to reduce the need for unnecessary movements.	20	50
Apps can be created to make easy the delivery of market and perishable products to people's homes.	10	25
Prayer as precautionary measure	30	75
Combination of scientific guideline and indigenous knowledge	32	80

Source: Field Survey, 2021

CONCLUSION

The study concludes that the 80% of the respondents practiced the following COVID-19 pandemic precautionary measures: social distancing, use of face masks, use of hand sanitizer. combination of scientific guideline and indigenous knowledge,while 75% practiced good hygiene, consume ginger and garlic, hydroxychloroquin and were holding prayer meetings as precautionary measure because they believed their God is a God of protection and can protect them. Therefore, this study concludes that the consumption of fruits and vegetables , personal hygiene, prayer to God as well as following precautionary measures are diverse strategies of reducing the Spread of COVID-19 . Therefore, this study recommends an integrated approach to solving COVID-19 pandemic.

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Food Consumption Pattern and Dietary Diversity among Rural Households in Kogi Local Government Area, Kogi State, Nigeria

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ABSTRACT

This study assess the food consumption pattern and dietary diversity of rural farming households in Kogi local government area of Kogi state, Nigeria. It specifically assess the food security status of households in the area, assessed the dietary diversity of households in the area and examined the relationship between food security and dietary diversity in the area. A three-stage random sampling technique was used to select 120 farming households for the study. Primary data obtained through structured questionnaire were analyzed using descriptive statistics and Poisson regression model. The result also showed that 71.67% of the households were food secure while 28.33% were food insecure. The study further revealed that 58.33% of the respondents fell in the high dietary diversity range, 29.17% had medium dietary diversity, while 12.5% had low dietary diversity levels. The coefficients of age (ß=0.775024), household size (ß=-0.1442771), dietary diversity (-3150306), and access to credit (ß=-2.662027) significantly determined the status of food security among farming households at 5%, 10%, 5%, and 1% level of measurement respectively. The study concluded that rural households with substantial level of educational influences dietary diversity score and improve the number of food secure household in the study area. It is however recommended that in order to reduce burden due to income constraint, food aids intervention should be created to help the rural households to have improved health by diet diversification.

Keywords: Food security, dietary diversity, dietary score, household

INTRODUCTION

Food is a basic necessity of life. Its vital role at the household level is obvious since it is a means of livelihood. Adequate intake of quality food is a key requirement for a healthy and productive life (Victoria and Benjamin, 2012). Dietary diversity is the number of different foods or food groups consumed by the household over a reference period not regarding the frequency of consumption. The reference period usually ranges from one to three days, but seven days is also often used (FAO, 2017), and periods of up to fifteen days have been reported (Administrative Committee on Co-ordination/subcommittee on nutrition, 2005). Dietary diversity is a health indicator to which household nutrition can be assessed and related to the quality of the diet consumed. Dietary diversity does not only ensure the consumption of a balanced diet and good health, it also enhances intake of other components like fiber and antioxidants and helps to reduce the rate of malnutrition in the population. Therefore, increasing dietary diversity most especially at household level is a viable tool to achieving the second sustainable development goals of zero hunger. Household dietary diversity is also used to determine the level of resources available in a household. Understanding household dietary diversity may therefore be an alternative easy pathway to estimate household food security (Ajani, 2010; Valiki *et al.*, 2013). The research was intended to assess socio-economic characteristics of the respondents; determinants of household and dietary diversity and the relationship between household food security and dietary diversity of rural households in the study area. It is against the above background, that this research was undertaken, because it becomes extremely important to analyze the households' food security and dietary diversity among rural food crop farmers in Kogi Local Government Area of Kogi State, Nigeria. The study is significant in the current parlance of development economics, especially in extending similar studies such as Adebayo (2012), Agwu and Oteh (2014); Amao and Ayantoye (2015) among others.

METHODOLOGY

Study Area

This study was carried out in Kogi local government area of Kogi state. The local government has an area of 1,498km² and a population of 115,900 at the 2006 census, projected to 202,670 people in 2016 (NPC, 2016). Politically, Kogi local government area is divided into three (3) zones namely; Zone A, Zone B, and Zone C. The Zones are further divided into two (2) Subzones each namely; Subzones A and B.

Population and Sampling Procedure

The population for this study comprised of farming households in Kogi local government area of Kogi state. Three-stage random sampling technique was employed in selecting the respondents. In stage one; all three Zones of interest were selected. In stage two; one (1) Subzone was randomly selected from each Zone giving a total of three (3) subzones. In stage three; two communities were randomly selected from each of the subzone giving a total of six (6) communities. And finally, twenty (20) respondents were randomly selected from each community giving a total of one hundred and twenty (120) respondents.

Method of Data Collection

The source of collection of data in this research work was primary sources and the main instrument used was a structured questionnaire supported with interview method to take care of respondents with no formal education.

Method of Data Analysis

The data was analyzed using descriptive statistics, inferential statistics and Poisson regression model.

Food security Index: Food security status was used to classify farmers into either food secure or food insecure. The food security line is the recommended daily per capita calorie intake of 2260 kcal (FAO, 1996). Farmers whose daily per capita calorie intake is up to 2260 kcal were regarded as food secure and those whose daily per capita calorie intake is below 2260 kcal will be regarded as food insecure. This method has been applied to several studies whose main focus was on food security (Babatunde *et al.*, 2007). The food security line is given as: $Z = \frac{Yi}{R}$

- - (1)

Where: Zi = food security status of ith farmers; Yi = daily per capita calorie intake of ith farmers; R = recommended per capita daily calorie intake (2260kcal) And, Zi = 1 for Yi greater than or equal to R; Zi = 0 for Yi less than R

Additionally, the shortfall/surplus index and the headcount ratio of food security were calculated for the sampled households based on the food security line. The shortfall index (P) measures the extent to which poor households are food insecure, while the headcount ratio measures the percentage of the population the household that are food insecure/secure.

Shortfall Index (P) = $\frac{1}{M}(\sum Gi) = \frac{1}{M}\sum\frac{(Yi-R)}{R}$ - - - - - - - (2)

Headcount Ratio (H) = $\frac{M}{N}$ … … (3)

Where: M = the number of food insecure households, Gi = per capita calorie intake deficiency for ith household, N = number of households in the sample

Food Dietary Diversity

The Household Dietary Diversity Score (HDDS) was used to determine this. Specification of the HDDS method is given below; the following twelve food groups are used to calculate the HDDS indicator:

A.	Cereals
B.	Roots and tubers
C.	Vegetables
D.	Fruits
E.	Meat, poultry, offal
F.	Eggs
G.	Fish and seafood
H.	Pulses, legumes and nuts
I.	Milk and milk products
J.	Oil/fats
K.	Sugar/honey
L.	Miscellaneous

Each food group is assigned a score of 1 (if consumed) or a score of 0 (if not consumed). The household score will range from 0 to 12 and is equal to the total number of food groups consumed by the household.

HDDS* = ∑ *(A+B+C+D+E+F+G+H+I+J+K+L) - - - - (3)

The average household dietary diversity score for the population of study can be calculated as follows: $\frac{\sum(\boldsymbol{HDDS})}{\boldsymbol{total\ number\ of\ households\ surveyed}}$ - - - - - - - **(4)**

The source of the data for the HDDS is based on a recall of food groups consumed by the household in the previous 24 hours, reported by the person primarily responsible for food preparation in the household.

Relationship between Food Security and Dietary Diversity

Examine the relationship between household food security and dietary diversity among rural households in the area was analyzed using Poisson regression model. The Poisson Maximum Likelihood Estimator requires that the data be Poisson distributed with density function of Poisson regression model as given by (Animashaun, 2012):

F (yi/xi) = $e^{-\lambda(x)}\lambda i(x)^{(y)}$

$$\overline{\Gamma\,(1 + yi)} \quad - \quad - \quad - \quad - \quad - \quad - \quad 1$$

Where;

$\lambda i = \exp(\alpha + X'\beta)$, $yi = 0,1$, i = the number/count of food eaten by the household, X = a vector of predictor variables

Following (Animashaun, 2012) the expected number of events, yi

$$E(yi/xi) = var[yi/xi] = \lambda = \exp(\alpha + X'\beta) \quad - \quad - \quad - \quad - \quad 2$$

For i = 1,2…………..m

Determinants of Household Dietary Diversity

Based on the model above, the implicit functional form of the model estimated to examine the determinants of dietary diversity is specified as:

$$Y = \alpha + \beta X_1 + \beta X_2 + \beta X_3 + \beta X_4 + e \quad - \quad - \quad - \quad - \quad - \quad 3$$

Where;

Y = household dietary diversity; X_1 = food security status; X_2 = Household size; X_3 = Household Income; X_4 = Age of household head, e = error term; α = constant; β = parameter coefficients to be estimated

RESULTS AND DISCUSSION

Food Security Status of Households

Result of food security status of households in the study area is presented in Table 1

Table 1: Food Security Status of Households

Variables	Food secure	Food insecure
Recommended per capita daily intake (R) is 2260 kcal		
Number of households	86	34
Percentage of households	71.67	28.33
Daily per capita calorie consumed	3,322.10	1,673.25
Food security index (Z)	1.46	0.74
Head count ratio (H)	0.72	0.28
Gap/shortfall index (P1)		0.36
Severity (P2)		0.13
Surplus index	0.39	

Source: Computed from Field Survey, 2021

Results in table 1 revealed that the benchmark recommended daily calories intake of 2260kcal (FAO, 2012). However, the headcount ratios shows that 71.67 percent of the households with an average daily per capita household calorie consumption of 3,322.10kcal were food secure. The shortfall/surplus index measures the extent of deviation from the food security line. Hence, households had a surplus index of 0.39 and the least shortfall index of 0.36 indicating that food secure household exceeded the calorie requirement by 39 percent while the food insecure household fell short of the recommended calorie intake by 36 percent. This disagrees with Adeniyi and Ojo (2013) who found that about 70% of rural farmers are food insecure.

Level of Dietary Diversity of Households

The distribution of respondents according to the level of dietary diversity of' households is presented in Table

Table 2: Level of Dietary Diversity of Households

Category	Frequency	Percentage
Low dietary diversity (1-4)	15	12.5
Medium dietary diversity (5-8)	35	29.17

High dietary diversity (9-12)	70	58.33
Total	120	100

Source: Field Survey, 2021. Adapted from Ajani, 2010

Dietary diversity was employed as a qualitative measure of food consumption in the study area. It reflects household access to a wide variety of twelve (12) food groups included in the Household Dietary Diversity Score (HDDS). Dietary diversity indices have been shown to be good proxies for calorie intake and nutritional outcomes (Ruel, *et al.*, 2013). The summary statistics of dietary diversity measures among the sample households revealed that 12.5 percent belonged to the low food diversity category, 29.16% belong to the medium food diversity category and 35.0% belong to the high food diversity category. Most of the respondents were farming households whose major source of livelihood has been drastically affected by numerous challenges in the study area. Households cultivate food crops with significant difficulty. Respondents were forced to consume a particular range of food groups available due to limited income diversification opportunities consequently, reduced economic access to food in adequate quantity and quality when own production depletes.

Relationship between Food Security and Dietary Diversity of Households

Estimates of the binary logistic regression of the relationship between food security and dietary diversity of households is presented in Table 3

Table 3: Binary Logistic Regression of the relationship between Food Security and Dietary Diversity

Food security	Coefficient	Std. Err	Z	p>|z|	Interval
Constant	3.590045	2.263286	1.59	0.113	8.026003
Age	-.0775024	.349707	-2.22	0.027**	-.008961
Gender	-.1106166	.6020095	-0.18	0.854	1.0693
Farming experience	1.236202	.302723	4.08	0.000***	1.829534
Household size	-.1442771	.0874105	1.65	0.099*	.0270443
Educational level	-.0029459	.0322983	-0.09	0.927	.0603577
Dietary diversity	-3150306	.1480308	2.13	0.0338**	.6051658
Access to credit	-2.662027	.6526394	-4.08	0.0007** **	1.382877
Number of obs	= 120				
LRChi2 (7)	= 83.42				
Prob > Chi2	= 0.000				
Pseudo R2	= 0.5080				
Log likelihood	=40.3999				

Source: Computed from Field Survey, 2021

The result of the analysis shows that the Chi square of the regression is 83.42 found to be statistically significant at 1% level. The model has a high Log likelihood of -40.3999; describing a model displaying a good fit, this shows that the explanatory variables in the estimated logit model significantly explain the likelihood of a respondent being food secure. The results show that Pseudo R^2 is 0.5080 (50.8%) of the seven variables explained and included in the model, five were significant. Five variables were significant out of the 7 independent variables namely Age, Farming experience in years, household size, dietary diversity and access to credit. Age and household size, dietary diversity and access to credit facilities were significant at 5%, 10%, 5% and 1% respectively but coefficients negatively signed. This implies that increase in age doesn't necessarily lead to increase in food security status neither dietary diversity of the respondents. Large household size with increased dependents members than the working adults tend to enhance food insecurity. It is pertinent that despite the intervention of the government in provision of credit resources, accessibility of credit from both formal and informal sources food insecurity still sustained which implies that respondents' access to credit facilities doesn't guaranty their food security or ability to diversify their diets. Years of farming experience was significant at 1% and coefficient (1.236202) positively signed. This implies that increase the years of farming of respondents reduce the incidence of food insecurity and tend to improve the dietary diversity of the respondents hence improvement in quality of livelihood. The study found a significant relationship between food security and dietary diversity which agrees with the findings of Faber, *et al.* (2009).

CONCLUSION AND RECOMMENDATIONS

This study concluded that about 71.67 percent of the respondents being food secure having a surplus index of 0.36 indicating that food secure household exceeded the calorie requirement. This reflect a favourable food pattern of households in the study this research extended its scope beyond just rural coverage. It was concluded that, dietary diversity score which is a good proxies for calorie intake and nutritional outcomes of individual households classified majority of the respondents to the medium category which implies, averagely households consumes minimum of 5 – 8 groups of food classes within 12hours basically, they are food diversified. Finally, the study found a strong relationship between the food security status and food diversity among respondents in the study area. The study recommended moderate household sizes be kept as lager household sizes were found to be more food insecure with less food diversified, this can be aided by health extension workers. Finally, intervention programmes like provision of palliative, availability of affordable and accessible loans, grants and subsidized farm inputs will positively influence the welfare of households by the government and relevant stakeholders.

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Perception of Microcredit Use of Turmeric Processors in South East, Nigeria.

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ABSTRACT

The inadequate processing technology caused by lack of funds has negative effects on food security. The perception of microcredit use by turmeric processors was assessed in south east Nigeria. A multi-stage sampling procedure was used in selecting ninety six respondents for the study. A well-structured questionnaire was used in collecting data from the respondents. The data collected were analysed using descriptive statistics. The results show that majority of the processors were female and are married. The processors are still in their active age and have a long time experience in processing business. The result reveals that the cost of getting microcredit was high and disagreed that only members in the cooperative assess microcredit. The study concluded that, microcredit should be made easier for assessment to processors. This study therefore recommended that male processors should be encouraged since it is a source of income for household. The cost of getting microcredit should be reduced to support turmeric processers in the business. Also, processers should be encouraged to engage in seminars that will provide information on easy access to micro-credit.

Keywords: Turmeric, Processers, Microcredit and Perceptions

INTRODUCTION

Turmeric (botanically known as Curcuma longa Linn) also known as the 'golden spice of life is a root crop in the same family as ginger. The root receives less attention from Nigerian farmers, despite having huge potential for local industries and export. It is used in the food, cosmetic and pharmaceutical industries. It is used as a spice and it is the major component of curry powder. Turmeric is also used in the cosmetics industry for its brilliant yellow colour and characteristic perfume. It is also used as a dye for colouring fabrics.

Turmeric is a seasonal crop and perishable (USAID 2017). It is an export crop because of its high demand in advanced medical and confectionery industries. Due to the lack of storage facilities, traders are forced to sell the product immediately after collection from farmers.

Microcredit facilities are established to help the rural households to tackle poverty and improve food security. Microcredit provides credit facilities at reasonable terms to the reach of rural dwellers. It increases the productivity of the rural sector, promotes and expands the rural economy in an organized and efficient manner (Sheremenko *et al.*, 2012). Microcredit to a low-income household can create new job opportunities, enable the poor to manage their limited

financial resources in a rational way and reduce unemployment (East and Southern Africa Banking Supervisors Group (ESAF), 2004; Javed et al., 2006; Latif et al., 2011; Stanila et al., 2014).
The objective of the study is todetermine the socio-economic characteristics of turmeric processors and assess the perception of microcredit use in turmeric processing in south east, Nigeria.

MATERIALS AND METHODS

The study was conducted in South-East States of Abia, Ebonyi and Imo of Nigeria. The area lies between Latitude 5^0 29^1, 5^0 32^1, and 6^0 20^1 N of equator and 7^0 01^1, 7^0 29^1, and 8^0 06^1 E Longitude of Greenwich meridian respectively. The states have a total land mass of 10,952,400ha. The South-East zone has over 16 million resident's populations (NPC, 2016). The zone is made up of five states, namely: Abia, Anambra, Ebonyi, Enugu, and the Imo States. It also has a rural population density of 173 persons per square kilometer (Iloka and Anuebunwa, 1995). About 60-70% of the inhabitants are engaged in agriculture, mainly crop farming, animal rearing, food processing, and farm produce marketing. The climate can be described as tropical with two clear, identifiable seasons namely, the wet and dry seasons. Farming, processing, and marketing are the predominant occupations of the people. The economy of the zone primarily depends on agriculture and commerce.

A multi-stage sampling procedure was used in selecting the respondents for this study. The target population was turmeric processors. The turmeric processors were randomly sampled. The first stage involved purposive selection of three states, namely Abia, Imo, and Ebonyi out of the five states in the South-East geo-political zone. These states were chosen based on their high-level activities onturmeric processing. In the second stage, four LGAswere purposively selected from each of the selected states, giving a total of twelve LGAs.These local governments are Isiala Ngwa South, Osisioma Ngwa, Umuahia North and Ikwuano LGAs from Abia state, Ivo, Afikpo North, Ebonyi and Ikwo LGAs from Ebonyi State and Mbaitolu, Ngor Okpala, Onu Imo and Okigwe LGAs from Imo state, giving a total of twelve LGAs.
In the third stage, two communities were purposively selected from each LGA based on the presence of microcredit activities, giving a sample of 24communities. In the fourth stage, one market was purposively selected from each community to give a total of 24 markets. In the fifth stage, multi-stage random sampling technique was used to select 4turmeric processors from each community. It was compiled with the aid of the community resident, extension agents and turmeric processors in the areas. This gave 96 turmeric processors in the areas.
Primary data were collected using well-structured questionnaires administered on turmeric processors that use microcredit. The data collected from the turmeric processors was analyzed using descriptive statistics such as percentage, frequencies distributions, mean and five point likert scales.

RESULTS AND DISCUSSION

The socio-economic characteristics of turmeric processors such as sex, age, marital status, level of education, processing experience, household size were discussed under this section.The result of the socio-economic characteristics of turmeric processors for microcredit users are presented in Table.1.

Table 1: Socio-economic characteristics of turmeric processors that used microcredit

Variables	Freq	Percentage
Sex		
Male	22	22.91
Female	74	77.08
Total	96	100
Age (years)		
21-30	11	11.46
31-40	26	27.08
41-50	37	38.54
51-60	18	18.75
61-70	4	4.17
Total	96	100
Mean		46.14
Marital status		
Married	54	56.25
Single	15	15.63
Divorced	9	9.38
Widow	18	18.75
Total	96	100
Education level (years)		
No formal Education	16	16.67
Primary Education(1-6)	20	20.83
Secondary Education(7-13)	48	50.00
Tertiary Education(14-19)	12	12.50
Total	96	100
Experience (Years)		
1-5	17	17.71
6-10	20	20.83
11-15	16	16.67
16-20	29	30.21
21-25	10	10.42
26-30	14	14.58
Total	96	100
Mean		11.32
Household size		
1-3	25	26.04
4-6	46	47.92
7-9	20	20.83
10-12	5	5.21
Total	96	100
Mean		

Source: Field Survey, 2021

The result in Table1 shows that majority (77.08%) of the turmeric processors who used microcredit were females and (22.91%)of processors are male. This could be that processing of turmeric requires less effort and not tedious for women to engage on. This is in line with the findings of Ezra *et al.*, (2017) which indicated that the domination of women in turmeric processing is due to low demands of time and efforts required to work in the enterprise.

The result shows that the mean age of microcredit users of turmeric processors was 46.14years. It was observed that the majority (65.62%) of the microcredit users of turmeric processors are in the age bracket of 31-50 years. This implies that turmeric processors are within the active working bracket. They are young people who can withstand stress involved in the processing of turmeric, and they are matured to take credit decisions that sustain the business.
The results obtained are in line with the findings of Kantiok, (2007) who opined that the majority of the agricultural enterprise actors are in their working age. Also, this is in line with the results of Udoh and Nyienakuma (2008). They opined that agriculturist within the active age groups would be able to withstand stress and put more time in various agricultural operations.
The result in Table 1 showed that the majority (56.25%) of microcredit users of turmeric processors were married. This result indicates that turmeric processing can be used to sustain the basic needs of families involved in the processing. This result agrees with Ojo and Jibowa (2008) that reported that married people being responsible, their views are likely to be respected within the rural communities as they decide on the use of agricultural inputs.

The result shows that the majority (83.33%) of the turmeric processors of microcredit users had one form of formal education or the other. The result shows that the majority of the processors are highly educated. This will enhance the management of turmeric processing in the study area. In processing, formal education allows the turmeric processors to understand the proper management of resources in processing. This finding agrees with the fact that high literacy level, western education facilitates the adoption of modern technologies and improved practices (Shehu *et al.*, 2014 and Offor and Nse-Nelson, 2015).

Experience is expected to have a significant positive impact on the managerial ability of the processors. The result in Table.1 shows the years of experience the processors had acquired over the years. The mean years of experience of turmericprocessors of microcredituser are 11.32years. This result is an indication that the ginger processors have been in processing over a long period and can be said that there are experienced. This implies that the more experience, the more committed and confidence they have in the processing. The finding also shows that the processors were aware of the merits and demerits associated with the business because of the long years of experience.
The study also shows that the majority of the processors in the study area had a household size of between 4-6 persons. This means that the processors in the study area have a large household size. This implies that the processors have the advantage of family labour. Higher household size is advantageous in processing as the members of the household aid in the processing activities (Effiong, 2005 and Idiong, 2005). However, higher family size does not necessarily translate to higher use of family labour, because some of the able young men may prefer other jobs.

Table 2:Perception of Microcredit Use of Turmeric Processors

Perception	SD	D	U	A	SA	Total	Mean
Cost of getting microcredit is high	11(10)	27(54)	10(30)	24(96)	24(120)	311	3.24
Only members in the cooperative assess microcredit	39(39)	43(86)	6(18)	3(12)	5(25)	228	1.88

Microcredit takes a lot of time to process	18(18)	24(48)	11(33)	14(56)	29(145)	300	3.13
Bureaucratic bottleneck for credit	14(14)	16(32)	20(60)	23(92)	23(115)	313	3.26
Microcredit is for the rich	45(45)	30(60)	10(30)	6(24)	5(25)	184	1.92
Microcredit is too hard to understand	25(25)	30(60)	10(30)	17(68)	14(70)	253	2.64
Availability of microcredit to market is too hard	28(28)	14(28)	14(42)	29(116)	11(55)	269	2.80
Microcredit operation is similar to other borrowing methods	28(28)	20(40)	17(51)	19(76)	12(60)	255	2.66
Microcredit is for the poor only	40(40)	31(62)	12(36)	8(32)	5(25)	195	2.03
The culture of your community tolerate microcredit	9(9)	9(18)	18(54)	26(104)	34(170)	355	3.70

Grand Mean: 3.0. Five point Likert scale: 1,2,3,4 and 5
Source: Field Survey Data, 2021

From the result on Table 2, it was discovered that the turmeric processors using microcredit agreed that cost of getting microcredit was high(M=3.24).The result also disagreed that only members in the cooperative assess microcredit. The respondents strongly opined that the culture of their community tolerated microcredit (M=3.70) use. This reveals that community are aware of the important of microcredit in the processing activities. Also the majority of the processors using microcredit show favourable attitude to microcredit use. The result also, agreed that they had overbearing bottleneck during the process of obtaining microcredit. Also, the availability of microcredit to market was too hard. The result also disagreed (2.03) that microcredit is for the poor and this agrees with previous research studies in literature opined that microcredit increase per capita household income (Imai and Azam, 2012). It also enhances households' multidimensional well-being and improves the living standards of rural dwellers (Adjei *et al.*, 2009 and Imai *et al.*, 2010). Finally, the result agreed that microcredit takes a lot of time to process. This means that the impression people have about getting microcredit is true and efforts should be made to reduce the processing time.

CONCLUSIONS

The study examined the perception of microcredit use of turmeric processors in south east, Nigeria. The result of socio-economic characteristics of turmeric processors using microcredit shows that the majority of processors are females and are married. The literacy levels were high among them and could enhance processing technology. The result also agreed that cost of getting microcredit was high and has overbearing bottleneck during the processing of the microcredit. Equally it disagreed that microcredit was for the poor. It is therefore recommended that male counterparts should be encouraged in the processing of the root since it generates huge income for household and serves as a means of livelihood. The cost of getting microcredit should be reduced to encourage more participation by turmeric processers. Turmeric processers should be encouraged to engage in seminars that will provide information on easy access to micro-credit.

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Assessment Of Smallholder Farmers' Participation In Digital-Based Advisory Service: A Case Study Of Myfarmbase Africa

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ABSTRACT

The conventional agricultural extension practice due to several factors is not effective in capturing the interest of the younger generation. Given the prevalence of digital and social media platforms among young people, these channels can be used to pique their interest in agriculture. The general objective of the study was to assess smallholder farmers' participation in a digital-based extension advisory service with a focus on MyFarmbase Africa while the specific objectives include: to describe the socio-economic characteristics of the farmers under MyFarmbase Africa, examine the farmers' awareness of MyFarmbase Africa programmes, identify the benefits farmers derive and determine the perceived constraints to participation. A total sampling procedure was proposed for the study however, only 121 responded from which data was collected using a questionnaire via Google form survey. Descriptive statistical tools and Chi-square was used to analyze the data. Majority of the respondents were young, tertiary education farmers. Majority were aware of only four of the nine programmes while the farmers awareness of the programmes had significant relationship with their participation. Quick access to agricultural information, support from other participants in the group, information about the latest, up-to-date agricultural innovations, great networking opportunities with key stakeholders, and a ready market were the top five benefits enjoyed by the respondents. The major constraints to participation were Epileptic or poor power supply which ranked 1st, Poor telecommunication service (Bad network) 2nd, and the high cost of data to access online information which ranked 3rd.

INTRODUCTION

Agricultural Extension also referred to as agricultural advisory services is an informal out of school education provided to farmers to boost their agricultural production. It helps to progressively bridge the gap between key actors such as organizations, research services, and agribusinesses and farmers (World Bank & OECD, 2013). Although pregnant with prospects, the conventional agricultural advisory service has been faced with challenges over the years (Nwalieji & Nnabueze, 2018; Ogunniyi, Babu, Balana, & Andam, 2020). However, in recent times, there have been the emergence of private agricultural extension advisory organizations that have greatly complemented the conventional extension services by providing services at better conditions in terms of mode of information dissemination, international partnerships and mentorships, easier funding and ICT usage among others (Barber, Mangnus, & Bitzer, 2018). MyFarmbase Africa is one of such private agricultural advisory organization that leverages digital technology to assist farmers and agripreneurs with easy accessibility to agricultural information, technology and skills while also connecting them to markets to sell their products (MFB, 2020). Particularly the youth whose strength and plausible innovative ideas can help boost productivity and replace the older farmers who are gradually been eased out by reason of their old age. Therefore, utilizing these digital platforms and devices could greatly capture the interest of young people as well as sustain the interest of young farmers currently in agriculture. The specific objectives were to:

1. describe the socio-economic characteristics of the farmers under MyFarmbase Africa
2. examine the farmers' awareness of MyFarmbase Africa programmes
3. determine the farmers' benefits from MyFarmbase Africa programmes
4. determine farmers' perceived constraints to participation in MyFarmbase Africa programmes

Hypothesis

H01: There is no significant relationship between socio-economic characteristics of smallholder farmers and their participation in MyFarmbase Africa.

H02: There is no significant relationship between smallholder farmers' awareness and their participation.

METHODOLOGY

Survey research design was employed for this research to assess smallholder farmers' participation in a digital-based extension advisory service with specific focus on MyFarmbase Africa. A total sampling procedure was proposed for the study to survey farmers under MyFarmbase Africa, hence the link to the google form was sent to all the cohort groups as at the time the research was carried out. However, only 121 respondents responded to the survey. Primary data were gathered from the farmers through the use of questionnaire disseminated via Google form. Descriptive statistical tools frequency tables, percentages, mean, standard deviation, and ranking were used to analyze the objectives. While the hypothesis were tested using Chi-square and Pearson correlation.

Results and discussion of findings

Table 4.1 Percentage distribution of respondents' Socio-economic characteristics

Variables	Percentage	Mean

AGE 21-40	 65.3	36.9
41-60	33.9	
60 Above	0.8	
SEX		
Male	62.8	
Female	37.2	
EDUCATIONAL LEVEL		
Primary education	1.7	
Secondary education	0.0	
Tertiary education	98.3	
INCOME (₦million)		1884223.7
<1	44.2	
1-5	51.2	
6-10	3.5	
11-15	0.0	
16-20	1.2	
PREFERRED MODE OF COMMUNICATION		
Physical contact	24.8	
WhatsApp	63.4	
Instagram	1.0	
Facebook Email	0 4.0	
All of the above	5.9	
All of the above except physical contact	1.0	
PARTICIPATION		
Low	58.7	
High	41.3	

source: field survey, 2022

The table above shows that the mean age is 36.9 and that majority 65.3% of the respondents were within the age bracket 21-40. This revealed that most of the farmers were young adults who were IT inclined, hence their access to and usage of digital devices for various purposes. The table reveals that majority 98.3% of the farmers had Tertiary education. Majority of the respondents are literates and have tertiary education. The table reveals that majority (51.2%) of the respondents made an income of 1-5 million naira a year. The mean income of the respondents for a year is ₦1,884,224 is probably high due to higher literacy levels. The more literate farmers are, the more knowledgeable they are to utilize more improved technology to boost agricultural productivity which in turn results in increased income.

The table revealed that majority of the respondents (63.4%) preferred WhatsApp platform a digital medium for receiving Extension information and Advisory service quickly. Although, a considerably significant 24.8% from the table above indicated that they would prefer if physical contact and one-on-one extension services could be provided too.

As revealed in the table above, majority (58.7%) of the smallholder farmers in MyFarmbase Africa had low participation in the programmes of MyFarmbase Africa despite their tech-savviness.

Table 4.2 Percentage distribution of Farmers awareness of MFB programmes

Programme	Yes (%)	No (%)
MFB Global Agricultural Development Programme (2 weeks Intensive online Boot Camp Training)	90.1	9.9
MFB Value Chain Specialization programme	72.7	27.3
MFB Backyard farm challenge	47.1	52.1
MFB Climate Smart Agriculture Programme	48.8	50.4
MFB Master Class	71.1	27.3
MFB Youth Annual Conference Programme	29.8	68.6
MFB Yearly Hangout	49.6	50.4
MFB Social Media Week Programme	30.6	69.4
MFB Market Square Programme	77.7	22.3

As shown in the table, majority of the farmers were aware of MFB Agricultural Development Programme (2 weeks intensive online Boot camp training) (90.1%), MFB Market Square (77.7%), MFB Value chain specialization programme (72.7%) and MFB Master Class (71.1%). Hence, more efforts need to be done to increase the farmers' awareness of these five (5) programmes.

Table 4.3: Percentage distribution of Smallholder farmers' benefits and constraints

Benefits	S.D	Mean	Rank
I get easy access to funding opportunities	1.12301	2.5868	6th
I get quick access to agricultural information	0.79148	3.9174	1st
Great networking opportunities with key stakeholders to move my business forward	0.87599	3.5372	4th
Ready market by selling my produce on the cohort group	0.94585	3.1736	5th
I share and get support from other participants	0.78071	3.8760	2nd
I get information about latest, up-to-date agricultural innovations	0.86372	3.7686	3rd

Constraints			
Epileptic or no power supply to power my gadgets	0.81267	2.0583	1st
Cost of data to access online information from MyFarmbase Africa is expensive	0.71707	1.9504	3rd
Poor telecommunication service (Bad network) in my area	0.73593	1.9917	2nd
I don't know how to use online platforms very well	0.36946	1.1157	5th
Extension services and Information given at MyFarmbase Africa do not meet my needs	0.55608	1.3388	4th

source: field survey, 2022

The result from table revealed that among others, there were five major benefits enjoyed by smallholder farmers' in MyFarmbase Africa and three main constraints faced by farmers under MyFarmbase Africa which affect their participation

Table 4.4: Chi-square analysis indicating the relationship that exists between Participation and socio-economic characteristics at 0.1 level of significance

Independent Variable	Chi-square (X^2)	DF	P	Decision
Age	1.5731	2	0.666	NS
Sex	0.7223	1	0.697	NS
Educational level	1.5208	3	0.467	NS
Income	53.3569	4	0.613	NS

source: field survey, 2022

Testing the hypothesis of smallholder farmers' socio-economic characteristics: The result shows that there was no significant relationship at the 0.1 level of significance, hence we will accept the null hypothesis I.

Table 4.5: Chi-square analysis indicating the relationship that exists between Participation and Awareness of the farmers at 0.1 level of significance.

Independent Variable	Chi-square (X^2)	DF	P	Decision
Awareness of MFB Global Agricultural Development Programme	6.1345	1	0.013	S
Awareness of MFB Value chain Specialization Class	3.6236	1	0.057	S
Awareness of MFB Backyard Farm Challenge	3.7935	1	0.150	NS
Awareness of MFB Climate smart Agriculture	2.5705	1	0.277	NS
Awareness of MFB Master Class	5.4598	1	0.065	S

Awareness of MFB Youth Annual Conference	4.4568	1	0.108	NS
Awareness of MFB Yearly Hangout	8.9449	1	0.003	S

Source: field survey 2022

The result of the table shows that there was a significant relationship between Participation and the farmers Awareness of MFB Global Agricultural Development Programme, Value chain specialization class, Master class, Yearly Hangout with values less than 0.1 level of significance, hence we will reject the null hypothesis.

CONCLUSION

The outcome of this study explained that majority of the respondents (65.3%) were young farmers who are well educated with tertiary education and have a high mean income of ₦1884223.7. Majority of the farmers (63.4%) farmers preferred WhatsApp, which is a digital mode of communication. However, a significant (25%) which is one-fourth of the respondents indicated that physical contact should be included too. Majority of the farmers were aware of only four programmes out of the nine programmes of MyFarmbase Africa while 58.7% of the farmers had a low Participation in MyFarmbase Africa programmes. The smallholder farmers under MyFarmbase Africa enjoyed quick access to agricultural information, support from other participants in the group, information about latest, up-to-date agricultural innovations from MyFarmbase Africa, great networking opportunities with key stakeholders as well as ready market by selling produce on the cohort group platforms. The top three constraints identified that affected their participation include Epileptic or poor power supply to power gadgets, followed by Poor telecommunication service (poor network) and then the high cost of data to access online information from MyFarmbase Africa. Finally, the farmers' awareness of MFB Global Agricultural Development Programme, Master Class, Value chain specialization and Yearly hangout had a significant relationship with their participation in the various programmes.

RECOMMENDATIONS

I. The farmers should look into alternative sources of power generation such as solar power to complement the current means of generating electricity to power their digital devices/gadgets.

II. Also, government and local community leaders should make demands on private telecommunications companies to improve their network coverage and network services to ensure fast and easy access to network.

III. Furthermore, MyFarmbase Africa should organize their farmers into groups to take advantage of bulk data purchase to reduce the cost of data and give more internet access to their farmers

IV. Private Agricultural extension advisory organizations should increase the awareness of their new and existing programmes among farmers so they can be fully aware to enable them to participate effectively in programmes that can improve their agricultural productivity. This can be achieved via jingles on WhatsApp, radio, adverts on television and posters on bill bards.

V. Finally, Private agricultural extension advisory organizations should include physical meetings and one-on-one contact with the digital extension services they provide to make the service more robust and effective.

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Analysis of women improved cassava processing technologies adoption in wushishi local government area. Niger state

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ABSTRACT
The work on the effect of adoption, socio – economic institutional technological factors and the level of adoption of improved cassava processing technologies by women in WashitaLocal Government Area of Niger State. Purposive]y choose three communities for this work. The 20% of the respondents from sampling frame of 760 was employed. The mean age was 35 years and 84% have formal education, 26% had extension contacts while 20% had access to loan facilities and 22% were in different associations. The average adoption level was 53% and regression analysis showed that age, household size, processing experience and membership of association were significant to the adoption. The coefficient of determination (R^2) was 0.47 which implies that 47%. The Z-stat (20.04) for output was greater than the Z-critical (1.98) while the Z-stat (24.30) for income was greater than the Z-critical (1.98) and both were significant at p<o.o5. The result of the Z-test statistics shows that adoption of improved cassava processing technologies brought higher output and income for the women cassava processors.
KEY WORDS: Adoption: Cassava: Processing: Technologies: Women:Wushi

INTRODUCTION
Cassava (*Manihotspp*) is starchy root crop in the family *euphorbiaceae* cultivated in West Africa. Nigeria was the highest producer of cassava in the world with 54 million tones oftuberous roots (FAO, 2014). Cassava is major raw material for small scale businesses such as cassava flour mills, bakeries, fast food firms, restaurants, gari processing firms and presently wealth generating activity (Odii, 2012).According toFAO (2004), Cassava farming continuous to expand formore years in both areas cultivationand yield per hectare. Cassava performs well in all parts of Nigeria. This is due to the improved, high yielding, pest and disease resistant varieties bred through research in collaboration with International Institute of Tropical Agriculture (IITA), Ibadan, National Root Crop Research Institute (NRCRI), Umudike and other research to mention but few. Some of the areas where the cassava is cultivated are the coast in the south to the middle belt. North central zone grows about6- 7 million tons of cassava in a year. Benue and Kogi states in the north central Nigeria are the largest producers of cassava

in the country (IITA, 2004).Women play major role in processing basic foodstuffs and also do 60-90% of the rural marketing; thus constitute more than two third of the workforce in agricultural activities(FAO, 1995; Rahman, 2004

METHODOLOGY

The research was conducted in Wushishi local Government area of Niger State.The research work was only on women that take cassava processing as occupation in Wushishi Local Government Area. Purposive samplings were used to select villages. The villages sampled are shown in the Table

1. The sampling was due to the active participation of women in cassava processing and 20% sampled.

Table1: Distribution of Respondents according to villages showing sampling frame and proportionate sampling size of respondents

Villages Selected	Population of women cassava processors	Sampling size 20%
Tsadozhiko	150	30
Lokogoma	160	32
Dukunsakun	196	39
Tangwagi	254	31
Total	**760**	**152**

Data was collected using enumerators that moved round the communities to locate the women processors. Information obtained from the women processors includes socio-economic status like age, educational status, marital status, household size and processing ideas. Institutional factors like number of contact with extension agents, loan collected and whether member of association or not. Analytical tools used were descriptive statistic like mean, frequency distribution, tables and percentages, regression analysis and Z- test statistics.

The model is specified as linear production function.

$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots\ldots + b_{11} X_{11} + e$

Where Y = Adoption of improved cassava processing technologies

X_1 = Age (in years)

X_2 =Marital status (married=2, single and other = 1)

X_3 = Educational status (years spent in school)

X_4 = Household size (number of persons)

X_5 = Processing experience (years spent in processing)

X_6 = Contact with extension agents (No. of visitation)

X_7 = loan obtain (amount in ₦)

X_8 = Membership of cooperative society (No. in years)

X_9 = Affordability of technologies (5- point Likert scale)

X_{10} = Compatibility of technologies (5 – point Likert scale)

X_{11} = Complexity of technologies (5- point Likert scale)

$b_1 - b_{11}$ = regression coefficients

a = Constant

e = error term

Z - Test statistic.

Z – Test is to examine the effect of adoption of improved cassava processing technologies on respondent's output and income before and after adoption of the technologies. The Z – test come in this form

$$Z = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where

Z= the calculated Z – value

$\overline{X_1}$= Mean income of women after adoption.

$\overline{X_2}$= Mean output/income of women before adoption.

S_1^2= Standard deviation of output/income of women after adoption

S_2^2 =Standard deviation of output/income of women before adoption.

n_1= No. of women cassava processors after adoption.

n_2= No. of women cassava processors before adoption.

RESULTS AND DISCUSSION

Adoption of improved cassava processing technologies level

Processor's level of adoption of improved cassava processing technologies is shown in bar chart form in fig 1 below.Improved cassava processing technologies adoptionmay have wide acceptance with more income projection in return. Technologies consider in this research work include mechanical grater, screw press, mechanical sifter as well as the fryer (toaster) which the processors were trained on. Mechanical grater 98%, mechanical sifter 83%Screw press and fryer (toaster) recorded 20% and 9% adoption level respectively. The mean level of 53% adoption was above average indicating improvement in adoption level of the improved cassava processing technologies.

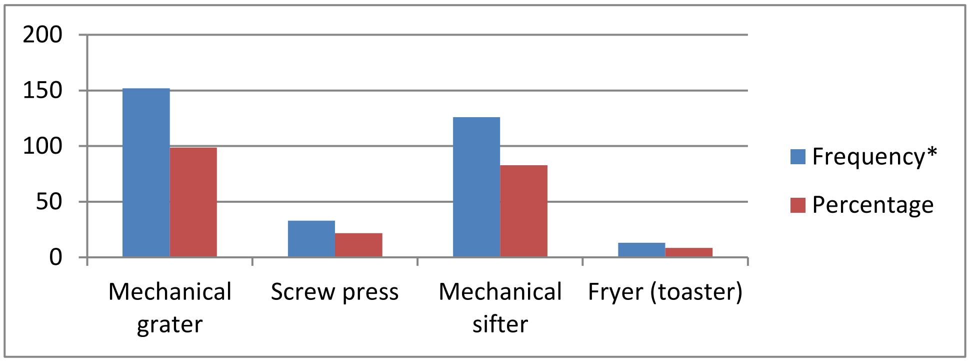

Figure 1: Respondents distribution based on level of adoption of improved cassava processing technologies.

Socio - economic, institutional and technological factors influencing improved Cassava processing Technologies adoption by Women in the Study Area.

The socio-economic factors viewed were age, marital status, educational level, household size and processing experience. The result in table 2 indicated three out of the five socio-economic factors chosen had significant effects on improved cassava processing technologies adoption. Age shows negative regression coefficient of 0.048 and proof to had significant effect on the improved cassava processing technologies adoption at 1% level of probability. The implication is the adoption level of the improved cassava processing technologies reduces with an increase in age. Household size indicated a positive regression coefficient of 0.118 and had significance effect on improved cassava processing technology adoption at 10% level of probability. The implication is that the adoption of improved cassava processing technologies increases with more number of household sizes. The increase in household size means efficient and easy division of labour.

In the study area the experience acquired by the respondents shows significantly a positive regression coefficient of 0.086 and significantly affected the adoption of improved cassava processing technologies at 1% level of probability. This means that adoption of improved cassava processing technologies increases as the years ofexperience increases too. Marital status proof to have no significant effect and has coefficient of 0.070. This means that being single or married has no influence on adoption of improved cassava processing technologies. Educational level gave positive regression coefficient of 0.019 but do not affect the adoption of improved cassava processing technologies. This means that be educated or not does not in any way affect processing of cassava. Age, household size, and processing experience had significant effect on adoption of improved cassava processing technologies.

Table 2Effects of socio-economic, institutional and technological variables on adoption

Variable	Coefficient	Standard error	t-value
Intercept	3.427	0.570	6.01***
Socio-economic variables			
Age	-0.048	0.017	-2.84***
Marital status	-0.070	0.081	-0.86NS
Educational status	0.019	0.017	1.14NS
Household size	0.118	0.064	1.83*
Processing experience	0.086	0.029	2.99***
Institutional variables			
Credit received	1.42e-06	1.46e-06	0.97NS
Membership of association	0.036	0.017	2.02**
Extension contact	0.131	0.083	1.57 NS
Technological variables			
Affordability	0.049	0.017	2.76***
Compatibility	0.017	0.018	0.96NS
Complexity	-0.051	0.023	-2.17**

$R^2 = 0.47$ NS=Not significant
$R^{-2} = 0.41$
F value = 4.778***

*** P<0.01, ** P<0.05, * P<0.10

The institutional variables in this research were loan taken, be a member of association and extension contact. Membership of association gave a positive regression coefficient of 0.036 and significantly has a direct effect on adoption of improved cassava processing technologies at 5% level of probability. Indicating that the adoption of improved cassava processing technologies increases with been a member of association. Loan taken and extension contact does not have any effect on adoption.
The technological factors in this research work include affordability, compatibility as well as complexity. Affordability gave a positive regression coefficient 0f 0.049 and show significant motivation on adoption of improved cassava processing technologies at 1% level of probability. This meaning that adoption continues to increase with the processors acquiring more equipment for these technologies. Compatibility also proofs a positive regression coefficient of 0.017 without significant impact on adoption of improved cassava processing technologies. Complexity will always give negative regression coefficient. The 0.051 coefficient shows significant influence on adoption at 5% level of probability. This means that adoption reduces as technologies become more complex.
The coefficient of determination (R^2) was 0.47. This implies that about 47% of the variations observed in the adoption of the improved cassava processing technologies were explained

by the selected socio-economic, institutional and technological variables, output and income included in the model. The remaining 53% could be attributed to other factors that were not included in the model.

Improve cassava processing technologies adoptions on product output and wealth of processors.

Paired t-test was employed comparing the mean product output and mean wealth before and after adoption of technologies by women processors in the study area.

Table 3: Shows the effect of adoption of technologies on the output of respondents.

	Output Before Adoption	*Output After Adoption*
Mean	71.052	163.158
Standard deviation	30.868	62.703
Observations	152	152
Pearson Correlation	0.685	
Hypothesized Mean Difference	0	
Df	151	
z Stat	-24.045	
P(Z<=z) one-tail	8.511E-54	
z Critical one-tail	1.655	
P(T<=z) two-tail	1.702E-53	
z Critical two-tail	1.98*	

*P<0.05

Table 3.Shows that average outputs before adoption was 71.05 .However, average output after adoption stand at 163.16. The standard deviation for both output before and after adoptions were 30.87 and 62.70 respectively. The calculated Z – value gave 24.04 and is greater than critical value Z - critical that gave 1.98 at 5% level of probability

Table 4.Show the influence of adoption of improve cassava processing technologies on the wealth of processors

	Income Before Adoption	*Income After Adoption*
Mean	298315.789	678736.842
Standard deviation	124204.1	260845.1
Observations	152	152
Pearson Correlation	0.713	
Hypothesized Mean Difference	0	
Df	151	
z Stat	-24.296	

P(Z<=z) one-tail	2.431E-54
z Critical one-tail	1.6550
P(Z<=z) two-tail	4.861E-54
z Critical two-tail	1.98*

*P<0.05

Table 4 the average wealth before adoption was₦298, 315.79 and after adoption gave N673, 736.84. The standard deviation before and after adoptions was N124204.1 and N2608451 respectively. The Z – cal was 24.30 and was greater than Z-critical of 1.98. For both output and wealth, the Z – cal gave greater figure than the Z critical. There exist significant difference between the product output and wealth before and after adoption of improved cassava processing technologies in the study area and corroborates the findings of Bakut (2013.

CONCLUSION

The work revealed that women cassava processors were young, 68% were married and all the factorsplay good role in the adoption of cassava processing technologies.

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Factors Influencing Adoption Of Fertilizer Usage Among Cassava Farmers In Delta State, Nigeria

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ABSTRACT
The study investigated the factors influencing adoption of fertilizer usage among cassava farmers in Delta State, Nigeria. The specific objectives were to: ascertain the factors influencing the adoption of fertilizer usage among the farmers determine the constraints working against fertilizer usage by the farmers and examine farmers' suggested strategies to improve the constraints working against fertilizer usage in the study area. Multistage sampling techniques were used in this study. However, 200 cassava farmers were used as the sample size. Findings of the study indicated that greater proportions (60%) of the farmers were male, while 40% of them were female. Results also showed that the majority (42.5%) of the farmers who cultivated cassava were married, 31.5% were single, 16% were divorced and only 10% were widowed. The average mean age of the cassava farmers was 39 years while the average household size was 8 persons. The mean year of cassava farming experience was 18 years while the average farm size for cassava farmers was 1.21ha. Out of the 13 variables investigated as the factors influencing the adoption of fertilizer usage among cassava farmers in the State, six (6) variables were found to be statistically significant in the study. The variables were educational level, farm size, farming experience, level of soil fertility, training received and extension service. The identified constraints in the study area were disease/past infestation, inadequate government support, high cost of cassava stems, weed infestation, bad road network, scarcity and high cost of land, lack of modern storage and processing, poor access to institutional credit, and inadequate extension services to farmers. In terms of strategies, finding also showed that a majority of the cassava farmers was of the opinion that having appropriate and effective information on fertilizer usage would improve fertilizer usage among farmers in the study. In view of these, this paper recommended that: More extension workers should be recruited by the state and federal governments to fill in the gap of inadequate agricultural extension workers in the study area. Government should help to provide storage and processing equipments to farmers.
Keywords: Cassava, adoption, farmers, influence, fertilizer.

INTRODUCTION

One of the major problems facing agricultural productivity in Nigeria is illiteracy. This has over the years posed great challenges to agricultural development as well as productivity. The level of literacy of farmers in Nigeria generally affects agricultural practices especially in the rural areas(Okpachu,Okpachu and Obijesi,2014). Although farmers usually have rich knowledge of local conditions and valuable practical knowledge or experience of how best to successfully exploit their environment, they require innovation, information generated from research and development to boost their productivity (Paltasingh and Goyari, 2018).They also observed that Agricultural messages could enhance the productivity of farmers when they have access to it. This could be achieved through well equipped adult literacy scheme designed for farmers not only to access the information but having potency to interpret and utilize them for optimum productivity.

Increased agricultural productivity depends primarily on accepting cultural and technological changes at rural farm level. Peasant farmers can achieve higher farm yields if they adopt improved farming techniques; but some new practices are sometimes complicated, making adoption difficult for non-literate farmers. To adopt and successfully use improved farming techniques, peasant farmers must understand them. This requires effective teaching by the agricultural extension service (Oduro-Ofori , Aboagye and Acquaye,2014). Therefore, extension education provides practical learning opportunities for rural people to acquire the necessary knowledge and skills that would enable them choose wisely, act productively, and grow individually while contributing to national progress.

Cassava (*Manihot esculenta*) is perennial woody shrub with a starchy edible root. It grows in tropic and sub-tropic regions of the world. The most commonly used part of cassava is the starchy root, which is rich in carbohydrates, about 20-30% dry matter. Cassava leaves can also be consumed and are rich in protein (14 - 40% dry matter), minerals, Vitamin B1, B2, C and carotenes (Mtunguja , Beckles, Laswai, Ndunguru and Sinha,2019). Cassava's growth characteristics make it a suitable food security crop, particularly due to its resilience growing in conditions that become unfavorable for other crops, such as periods of erratic rainfall. Due to this resilience to adverse environmental conditions, cassava has been named as an ideal climate change crop.

The basic goal of agricultural development organizations is to influence farmers to adopt agricultural innovations (Udemezue and Agwu,2018). The transfer of innovation and knowledge from research unit to farmers will bring about development. Therefore, the basic role of agricultural extension agent in the transfer of technology is to assist farmers in putting the readymade technologies into practice. Adoption is the decision to make full use of an innovation as the best course of action available. Adoption of agricultural innovations in developing countries attracts considerable attention because it can provide the basis for increasing production and income (Udemezue and Agwu, 2018).

There are several constraints to the adoption of technologies by farmers. Here an attempt has been made to outline the major constraints to adoption. According to Iwuchukwu,Obazi,Opata and Madukwe (2022), crop production in Nigeria is still plagued by myriads of setbacks ranging from difficulty in land acquisition, paucity of agricultural information and communication, inadequate training, issues of inappropriate technology, environmental constraints, pests and diseases, inadequate manpower, storage problems and irregular supply of improved seeds, inadequate supply of inorganic fertilizers and other production inputs (Mohammed, Ibrahim, Hayatu and Mohammed, 2019)

According to Carolyn,Afolam , Abiodun Obayelu and Vaughan(2015),Low adoption of modern agricultural technologies amongst farmers in Nigeria has been identified as one of the main reasons for the low agricultural productivity and increase in poverty level.To increase productivity, technology must be adopted in the production process and the rate of adoption of a new technology is subject to its profitability, degree of risk associated with it, capital requirements, agricultural policies and socioeconomic characteristics of farmers .

Soil infertility and low use of chemical fertilizer have been seen as two major factors inhibiting productivity growth of agriculture in Africa(Udemezue,Nwalieji and Nnena,2017). Fertilizer is one of the most essential farm inputs for increasing food production in the universe (Jaja & Barber, 2017). It is the quickest practical way to provide sufficient plant nutrients to restore nutrient-depleted in the soils (Raimi, Adeleke & Roopnarain, 2017).

In recent time, it has been observed that farmers in the state rejected application of fertilizer on their cassava farm despite the information disseminated to them on the need of application the innovation for higher productivity by extension worker. In view of this, the study investigated the factors influencing adoption of fertilizer applications by cassava farmers in Delta State, Nigeria. The specific objectives are to; ascertain the factors influencing the adoption of fertilizer usage among the farmers determine the constraints working against fertilizer usage by the farmers and examine farmers' suggested strategies to improve the constraints working against fertilizer usage in the study area.

Methodology

The study area is Delta State of Nigeria. The State covers a landmass of about 18,050 km^2 (6,970 sq mi), of which more than 60% is land. The State lies approximately between 5°00' and 6°45' E and 5°00' and 6°30' N. It is geographically located in Nigeria's mid-west, bounded in the north and west by Edo State, the east by Anambra, Imo, and Rivers States, southeast by Bayelsa State, and on the southern extreme is the Bight of Benin which covers about 160 kilometres of the state's coastline. The state produces crops like maize,yam,cassava,water melon etc and other economic trees. There are 25 local government in the state with head quarter at Asaba(Isorhovoja,2015).

Multistage sampling techniques were used in this study. Four (4) local governments out of the 25 local governments in the State were used for the research based on their activities on cassava production. Here, Aniocha North, Aniocha South, Ndokwa East and Ndokwa West were selected. These gave a total of four local government used for the study. Five communities per L.G. were purposefully selected due to their active participation in farming activities.Isele Asagba,Isele Ukwu,Onicha-Ugbo,Anioma and Uburubu from Aniocha North;Nsukwa,Abo Oguashi,Ewulu,Isheagwu And Ejeme From Aniocha South;Obi-Igbo,Umutu,Ashaka,Iseogboko And Ossaissa From Ndokwa East; And Amoji,Ogbe-Ogume,Umuchime,Ogbeani and Obodougwa From Ndokwa West were used. This gave a total of 20 communities used for the study.Ten (10) farmers each was randomly sampled from each community and this gave a total sample size of 200 farmers that were used for the work. Data used for this research were collected through a structured questionnaire. Data collected were analyzed using, frequency, percentage,mean score and regression model.

RESULTS AND DISCUSSIONS

Socio-economic characteristics of cassava farmers

Table1 shows that greater proportions (60%) of the farmers are male, while 40% of them are female. The implication is that males dominated their female counterpart in cassava production activities in the study area. This finding is in line with that of Diana(2015) who reported that women were found to contribute less in cassava production activities.

Entries in Table1 show that 47.59% of the farmers are within the age range of 46-55 years while 35% of them are within the age range of 25-35 year. Those who were within the age range of 46-55 were 12.5% while others who were within the age range of 56-75 were 12.5%. The average mean age of the cassava farmers was 39years. This implies that young people of active age dominated the activities of cassava production in the area.

Results also show that the majority (42.5%) of the farmers who cultivated cassava were married, 31.5% are single, 16% divorced and only 10% are widowed. Majority of the farmers who married could be an indication that they relied heavily on cassava for several household needs such as food, school fees for education, and health services for their families. Married people engaged more in cassava production activities than unmarried people because they have more responsibilities than unmarried ones. However, another implication of the married people engaged more than the unmarried could be that the couples are likely to be more productive than the single person due to labour supply in farm activities and access to productive resources in agriculture. This result is in consonance with that of mende kyanize and MW atawala(2015) that married people were likely to be more productive than single persons due to supply in farm activities.

Table1 shows that the majority (42.5%) of farmers completed secondary school education, 29% of the farmers completed primary school education and 14.5% of them stopped their education at first degree and above. The remaining 14% of the cassava farmers obtained OND/HND respectively. Education has always been known to play a good role in the adoption process, because people who are educated are more likely to adopt an innovation more readily than uneducated ones. In the same vein, a literate household head will be relatively less technophobic to adopt a new agricultural practice than one headed by an illiterate. Therefore, low level of education among the farmers imposes serious implications on their ability to access information, use new technological innovations and even access to get credit from formal financial institution (Mende,2015).

Finding shows that 41.5% of the cassava farmers had family size ranging between 6-10 persons, 37.5% of them had family size ranging between 1-5 persons, 11%of the farmers had family size between 11-14 and 10% of the remaining cassava farmers had family size ranging between 15-19 persons. The average household size was 8 persons. This means that the cassava farmers had relatively large family size and this may afford them the opportunity to increase their farm size and adopt more innovations exposed to them, since they will be able to make full use of family labour that can reduce the cost of hired labours for cassava production activities. This result agreed with that of Asmelash(2014) that the number of people in a household is the factor that influences the adoption of the technology, the bigger the size of the family in a household, the higher the chance of adoption as labour accessibility increase, adoption is also expected to increase. On the other hand, a large household size could also worsen the poverty situation of farming household especially if it was composed of a large number of the dependents, which means the family had more mouth to feed. A greater proportion (46.5%) of the cassava farmers cultivated between 1-2ha, 29% of them cultivated less than 1ha, 12.5% of the farmers cultivated between 3-4ha and 7.5% of the cassava farmers cultivated between 5-6ha respectively.

Similarly, 4.5% of the interviewed farmers cultivated between 7-8ha, while the average farm size for cassava farmers was 1.21ha. This implies that all the interviewed cassava farmers in the state were small-scale farmers. This could also help the respondents to have more access to a relatively large farm land that could be used in cultivation of crop to guard against failure that may arise from sole cropping. This result is in line with that of Mba, Saror and Agada (2016) that small scale farming offers the respondents an opportunity to have access to a relatively large farm land which may be used in cultivation of other crops in Venue state.

On the other hand, the majority (34.5%) of the cassava farmers had between 5-8years of farming experience while 34% of them had between 9-12years of farming experience. Similarly, 24% of the cassava farmers had between 1-4years of farming experience, 5% of the farmers had between 17-20years of farming experience, while 2.5% of the remaining cassava farmers had between 13-16years respectively. The mean years of cassava farming experience were 18years. This implies that the farmers had a very long period of farming experience and this will as well help them to acquire experience that will enable them to improve their activities in family farming.

A greater proportion (49%) of the cassava farmers had family and hired labour as the main source of labour in the farm, while 42.5% of the farmers used hired labour as their source of labour. On the other hand, 60% of the farmers got their farm land through renting while 25% of them got farm land through inheritance. Since majority of the cassava farmers sourced their farm land through rent, this could reduce the farmers capacity to increase farm size and this could as well impairing the adoption of new technologies disseminated to farmers. Majority (62.51%) of the farmers belonged to social organization while 60% of the farmers did not have access to credit loan. However, a greater number (65%) of the cassava farmers did not have access to agricultural extension services while some (35%) of the cassava farmers had access to agricultural extension services.

Access to credit loan is one way of improving farmers' access to new production technologies, according to one of the respondents, he said that farmers who have access to credit loan can reduce their financial constraints and be able to buy input more readily at the prevailing price. Therefore, it is expected that access to institutional credit can increase the taste of adopting improved technologies. However, since majority of the cassava growers in the study area did not have regular contacts with an extension agent, this could make them miss some vital information and technologies associated with cassava production activities. Those farmers that had contacts with extension services are expected to be more exposed to relevant technologies such as new released of improved cassava varieties or other technologies relevant to their family farming. In terms of social organization, participation in social organization could be advantageous to farmers, because farmers' social organization offers an effective channel for extension contact with large number of farmers as well as creating opportunities for interactions with organizations. This could also increase farmers' update of new practices such as cassava production technologies. More so, the majority (56%) of the farmers sourced cassava items from their harvested previous farms (owned farm) while 26% of them sourced from their fellow farmers. Similarly, 15% of the farmers sourced cassava stems from ADP while 3% of the remaining farmers sourced cassava stems from extension agents. Access to agro input could increase the probability of adopting an improved technology. It shows that even if a farmer is aware of a technology, access to it is also of paramount in adoption process.

Table1: Socio-economic characteristics of cassava farmers

Variables	Frequency	Percentage	Mean
Sex			
Male	120	60.00	
Female	80	40.00	
Age			
25-35	70	35.00	
36-45	95	47.50	
46-55	25	12.50	39years
56-75	10	5.00	
Marital status			
Married	85	42.50	
Single	63	31.50	
Devoiced	32	16.00	
Widowed	20	10.00	
Educational levels			
Primary school	58	29.00	
Secondary school	85	42.50	
OND/HND	28	14.00	
First degree and above	29	14.50	
Household size			
1-5	75	37.50	
6-10	83	41.50	8 persons
11-14	22	11.00	
15-19	20	10.00	
Farm size			
Less than 1ha	58	29.00	
1-2ha	93	46.50	
3-4ha	25	12.50	1.21ha
5-6ha	15	7.50	
7-8ha	9	4.50	
Farming experience			
1-4yrs	48	24.00	
5-8yrs	69	34.50	
9-12yrs	68	34.00	18yrs
13-16yrs	5	2.50	
17-20yrs	10	5.00	
Source of farm land			

Inherited	50	25.00
Rented	120	60.00
Gifted	30	15.00
Sources of farm labour		
Family	10	5.00
Hired	85	42.50
Family and hired labour	98	49.00
Exchange labour	7	3.00
Membership of social organization		
Yes	125	62.50
No	73	37.50
Access to credit loan		
Yes	80	40.00
No	120	60.00
Access to extension services		
Yes	70	35.00
No	130	65.00
Sources of cassava stems		
ADP	30	15.00
Extension agent	6	3.00
Fellow farmers	52	26.00
From farmer's previous farm	112	56.00

Source:survey,2022

Factors influencing adoption of fertilizer usage among cassava farmers in Delta state.

Liner regression model was conducted to predict the factors influencing adoption of fertilizer usage among cassava farmers in Delta State. The socio-economic variable used were age, educational level, sex, family size, farm size, farming experience, level of soil fertility, income, perceived constraints, training received, farming system practiced, extension services and types of tillage system used.

Out of the 13 variables investigated as the factors influencing the adoption of fertilizer usage among cassava farmers in the State, six (6) variables were found to be statistically significant as the factors influencing the adoption of fertilizer usage among cassava farmers in Delta state. The variables were educational level ($p<0.009$), farm size ($p<0.001$), farming experience ($p<0.004$), level of soil fertility ($p<0.000$), training received ($p<0.000$), and extension service ($p<0.007$).The decision was based on the value of R^2 (0.751) and adducted R^2 (0.642) that supported the claim of the dependent variable at 95%levels confidence.

Education level

Level of education is one the positive variables in the adoption of improved technology. Formal education helps the farmers to obtain useful information from radio, internet, agricultural news letter and other sources. Former education usually aids famers and lead them to accept new farm technologies more readily to increase their income than those farmers without a formal education. In developing countries, a general characteristic of famers is that they are tradition bound. They are afraid of taking risk and will not take until they are convinced that the new methods are safe, will pay and will not violate their values. However, most famers are tradition bound because of their low levels of education. Farmers are responsive to change provided it paid them and did not conflict with their value system. Hence literate farmers tend to adopt innovation more readily than illiterate farmers. In the light of the above, this finding is in line with the result of Okeke, Mbah, Madukwe and Nwaliej,2019) which saw education as one of the factors that trigers farmers' participation in improved sweetpotato farming. According to Okeke,*et al* (2019) the level of education attained by a farmer is not only increased his farm productivity but also enhanced his ability to know and evaluate more about the new technologies exposed to him.

Farming experience

Years of farming experience was positively significant and related to the factors influencing adoption of improved technologies in the study area. The implication is that the high level of farming experience among the farmers is expected to bring about a positive influence on adoption. That is, the more their farming experience, the higher the probability of adoption of the recommended improved production practices. Farming experience is an important determinant of the farmers' level of farm income. Farming involves a lot of risks and uncertainities, so to be competent enough to handle all the vagaries of agriculture, farmers must have a long farming experience(Garba,2016).

Farm size

The coefficient of farm size was found to be negative and statistically influenced the adoption of improved technology practices. This implies that as the farm size increases,adoption of the recommended improved technology practices also increases. According to Garba(2016),farm size has bearing on the capacity of farmers to adopt improved technologies and new farm practices. Farmers who have large farm size can afford to allocate part of their farm for yam production without significantly affecting the total land left for the production of the staple food crops compared to small land holder. This corroborates the findings of Tijjani,Tijjani and Audu (2018) which suggests a positive relationship between awareness and farm size among farmers in Jere LGA of Borno State.

Training received is positively and significantly related to the determinants of fertilizer usage among rice farmers. This implies that the contribution of explanatory variables is inversely proportional to dependent variable. Therefore, the more training received on fertilizer technologies, the higher the adoption of it. Farmers who receive adequate training on an innovation are more likely to adopt it than those who did not attain training. This finding agreed with that of Udemezue ,Nwalieji and Nenna(2017) who found training to be positively significant to adoption of fertilizer usage among rice farmers in Anambra State. This is because training improves farmers' level of knowledge and having agriculture as the main occupation will also help the farmers to seek for productive improved technology like fertilizer to increase productivity.

Level of soil fertility has a negative influence on determinants of fertilizer utilization among rice farmers. This implies that the more fertility land is the lesser fertilizer application on it. It is also could be that the farmers have exhausted all the available nutrients in the soil due to constant farming practice on one piece of land without fallowing. Therefore, if the fertility of soil is high, less fertilizer will be applied on it. The result agrees with that of Udemezue ,Nwalieji and Nenna(2017) which regard soil fertility as significant to the determinants of fertilizer adoption by rice farmers in Anambra State, Nigeria.

Extension contact has a positive influence on the determinant of productivity level among farmers. This shows that frequent contact with extension agent by farmers gives them the opportunity to know about the use of new farming techniques to increase their productivity level while negative contact with extension workers will affect their productive rate due to the fact that they might have missed information or the basic inputs needed to increase production. Regular contact with extension agents makes farmers being aware of new techniques and how they can apply them to increase production. This finding agrees with Udemezue and Nwalieji (2017) who found extension visit to be statistically significant to determinant of productivity level among cassava farmers in Anambra State, Nigeria.

Table2: factors influencing adoption of fertilizer usage among cassava farmers in delta state

Variables	Unstandardized coefficient		Standardized coefficient		
	B	Standard error	Beta	T	Sig
Constant	1.697	0.572	-	2.669	0.006
Age	0.002	0.013	0.020	0.270	0.795
Educational level	-0.208	0.075	-0.446	2.339	**0.009**
Sex	0.350	0.261	0.113	1.345	0.185
Household size	-0.819	0.0361	-0.222	-2.321	0.034
Farm size	-0.624	0.409	-0.452	3.988	**0.001**
Farming experience	1.273	0.144	0.723	8.828	**0.004**
Level of soil fertility	-1.635	0.200	-0.032	-0.390	**0.000**
Income	0.047	0.276	0.013	0.175	0.815

Perceived constraints	0.054	0,033	0.128	1.643	0.107
Training received	-0.938	0.179	0.441	-5.225	**0.000**
Farming system practiced	-4.115	0.003	-0.042	-0.290	0.697
Extension service	0.841	0.286	0.251	2.949	**0.007**
Type of tillage system used	0.054	0.033	0.119	1.343	0.194

Source: Field survey, 2022.R=0.865, R2=0.754, Adjusted R^2=0.642

Constraints to cassava production in Delta State.

Entries in Table 4 show the identified constants to cassava production in Delta State, Nigeria. The decision was based on the mean cut-off of 2 and above for 3-points Likert-type scale. Using mean score to rank the constraints items according to their order of severity were disease/past infestation (M=4.73), inadequate government support (M=4.52), high cost of cassava stems (M=4.51), weed infestation (M=3.95), bad road network (M=3.81), scarcity and high cost of land (M=3.55), lack of modern storage and processing (M=2.89), poor access to institutional credit (M=2.35), and inadequate extension services to farmers (M=2.13)

Table4: Constraints to cassava production in Delta State

Variables	Mean
Diseases/pest infestations	4.75
Inadequate government support	4.52
High cost of cassava stems	4.50
Weed infestations on the crop	3.95
Bad road network	3.81
Scarcity and high cost of land for cassava farming	3.55
Lack of modern storage and processing facilities	2.89
Imitated extension services to farmers	2.13
Long life cycle of the crop	1.81
Poor soil fertility	1.63
High cost of information to farmers	1.55
Age of the farmers	1.43

Low output from the crop	1.40
Use of local variety instead of the improve ones	1.35
High cost of inputs and labour	1.32
Too much attention on other crops like maize and yam	1.29
Low knowledge of the farmers on the multiple use of cassava crop	1.10
High perishability of the crop	1.09
Poor marketing outlet	1.05

Source: field survey, 2022.

Suggested Strategies to Improve Fertilizer Application among Cassava Farmers in Delta State.

Table3 shows that a majority (95%) of the cassava farmers was of the opinion that having appropriate and effective information on fertilizer usage would improve fertilizer usage among farmers. High cost of fertilizer has been reported by the farmers as a barrier to fertilizer usage in that area. In this case, 82% of farmers suggested that reducing the cost of it would help farmers to apply fertilizer on their farm. Also, 80.3% of the farmers were of the view that decentralization of training on fertilizer application among cassava farmers cannot only induce farmers to make use of fertilizer in their farms but also will place farmers on the platform of technical-knowledge of the technology. However,75% of the cassava farmers pointed out that administering training on farmers on the right application rate will encourage farmers to use fertilizers on their crops. Farmers were afraid to use it may be because some of them lacked the knowledge of its application rate and this can cause substantial disadoption of the innovation by the farmers. On the other hand,73% and 70% the interviewed farmers were of the opinion that conducting training on time of fertilizer application and strengthening the existing farmers organization through proper coordination and linking them to financial institution for loan assessment could help farmers to adopt fertilizer application in their farm. More so, 59% and 55% the farmers suggested the constraints to fertilizer application could be improved through the establishment of input centers at the village level for easy assessment. However, ministry of agriculture and other agencies involved in fertilizer packages should play active roles in coordinating and supervising of fertilizer released to farmers by government to get the right hands of the end-users this is because agricultural inputs released to farmers by government are sometimes being diverted and hijacked by politicians without getting to the appropriate farmers. Based on this, it is of utmost important to keep supervision of fertilizes released to farmers by the government.

Table4: Strategies to improve fertilizer usage among cassava farmers in Delta State

Variables	Percentage
Having appropriate and effective information on fertilizer usage on cassava farming	95

Reducing the high cost of fertilizer	82
Decentralization of training on fertilizer application among cassava farmers	80
Training on the right application rate	73
Payment of fertilizer subsidies by the government	38
Fixing of official price per a bag of fertilizer by government	28
Use of unbiased tax force to monitor price fixed by the government	42
Strengthening the existing farmers'cooperatives through proper coordinating and linking them to financial institutions for easy access to credit	70
Encouraging farmers to increase farm size	25
Establishment of input centre at the village level for easy access to fertilizer	59
Establishment of village information centre for current information on fertilizer usage	90
Encouraging farmers to commercialize their farming system	35
Regular and timely release of fertilizers to farmers	20
Increasing the number of extension staff for winder coverage and effective performance	45
Ministry of agriculture and other agencies involved in fertilizer packages should play more roles in coordinating and supervising of fertilizers released to farmers	55
Due process advocacy has to be accelerated	15
Farmers should be acquainted with the soil knowledge analysis before planting of crop	32

Source: field survey, 2022.

CONCLUSION AND RECOMMENDATIONS

Increased agricultural productivity relies on accepting cultural and technological changes at rural farm level. Peasant farmers can achieve higher farm yields if they adopt improved farming techniques; but some new practices are sometimes complicated, making adoption difficult for non-literate farmers. To adopt and successfully use improved farming techniques, peasant farmers must understand them, this requires effective teaching by the agricultural extension service. Based on these, findings of this indicated that greater proportions (60%) of the farmers were female, while 40% of them were female. The average mean age of the cassava farmers was 39years. This implies that young people of active age dominated the activities of cassava production in the area. The average household size was 8 persons. This means that the cassava farmers had relatively large family size and this may afford them the opportunity to increase their farm size and adopt more innovations exposed to them, since they will be able to make full use of family labour that can reduce the cost of hired labours for cassava production activities. The mean years of cassava farming experience were 18years. This implies that the farmers had a very long period of farming experience and this will as well help them to acquire experience that will enable them to improve their activities in family farming.

Out of the 13 variables investigated as the factors influencing the adoption of fertilizer usage among cassava farmers in the State, six (6) variables were found to be statistically significant as the factors influencing the adoption of fertilizer usage among cassava farmers in Delta state. The variables were educational level, farm size, farming experience, level of soil fertility, training received and extension service.

On the other hands, the identified constraints in the study area were disease/past infestation, inadequate government support, high cost of cassava stems, weed infestation, bad road network, scarcity and high cost of land, lack of modern storage and processing, poor access to institutional credit, and inadequate extension services to farmers. However, finding showed that a majority of the cassava farmers was of the opinion that having appropriate and effective information on fertilizer usage would improve fertilizer usage among farmers.

RECOMMENDATIONS

More extension workers should be recruited by the state and federal governments to fill in the gap of inadequate agricultural extension workers in the study area.

Government should help to provide storage and processing equipments to farmers. When this is done, it will reduce the high perishability of the product.

Rehabilitation of the existing roads by the government is necessary; this will help to transport the goods from the farms to markets.

Distribution of farm inputs such as cassava stems in the area is necessary; this will reduce the scarcity of cassava stems by the farmers.

Trainings should be organized by extension workers to teach farmers on how to ward off weed infestation using herbicides.

Fertilizer producers/industries should research critically on the active ingredient that caused weed infestations and correct the abnormality to make it acceptable by the farmers.

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Effect of Post-Harvest Losses of Maize Value Chain in Egbeda LGA, Oyo State

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ABSTRACT

This research was conducted in Egbeda local govt, Oyo state on the causes of post-harvest losses and the effects on the maize value chain. Data was collected using questionnaires and was analyzed using descriptive statistics and ordered probit analysis. A total of 120 farmers were interviewed. The post-harvest losses of maize were grouped into four categories; Low loss, minimum loss, medium loss and high loss. Results showed that the majority of post-harvest losses among the maize farmers occurred during harvest, de-husking, transportation, shelling, selling and storage. Education, marital status, farm size and external training on postharvest loss management were also observed significant variables that affected post-harvest losses. The study recommends that farmers should be properly educated on improved methods of harvest and processing so as to reduce these losses and the farmers should adopt improved practices that can minimize post-harvest losses

INTRODUCTION

The most widely cultivated grain crop in the Americas is maize (*Zea mays L*), sometimes known as corn, which was domesticated by native peoples in Mesoamerica in prehistoric times. The United States alone produces 332 million metric tons of maize annually (Raouf, 2011). Maize has several uses, such as a source of food, alternative medicine, chemicals, biofuel, and Sornaments. Food production cannot meet the rising food demand, according to the FAO (FAO, 1998), unless post-harvest losses are reduced. As a result, there will be a chance to produce a sizable amount of food for consumption and other purposes. While most of the increasing food production is happening in wealthy countries, the majority of post-harvest losses are happening in underdeveloped countries.

SAMPLING METHOD

Multistage sampling was used to collect data. Purposive sampling was then used to select Oyo state that is well known for maize production. One local government (Egbeda) that is prominent in maize farming was selected using purposive sampling. Six communities namely; Egbeda, Osegere/Awaye, Olodo, Owobaale, Ayede/Alugbo and Erumu with the highest population of maize farmers were selected using purposive sampling. Twenty (20) Maize farmers were randomly selected from each of the six communities making a total of 120 respondents.

METHOD OF DATA ANALYSIS

The Ordered Probit model is a widely used approach to estimating models of ordered type which almost employs the Probit link function. Y* is a linear combination of some predictors, X, plus a disturbance term that has a standard Normal distribution:

$$Y_i* = X_i\beta + \Sigma$$

The latent variable Yi* exhibits itself in ordinal categories, which could be coded as 0, 1, 2,…, k. The response of category k is thus observed when the underlying continuous response falls in the k-th interval as:

$Y* = 0$ if $Y* \leq \delta 0$

$Y* = 1$ if $\delta 0 < Y* \leq \delta 1$

$Y* = 2$ if $\delta 1 < Y* \leq \delta 2$ (2)

Where Y* (i=0, 1, 2) are the unobservable threshold parameters that was estimated together with other parameters in the model. When an intercept coefficient is included in the model, Y= 0* is normalized to a zero value (Green, 2000) and hence only k-1 additional parameters are estimated with Xs. Like the models for binary data, the probabilities for each of the observed ordinal response which in this study had 3 responses (0, 1, 2,) will be given as:

$$prob(Y = 0) = P(\beta' X + \Sigma_i \leq 0) = \phi(-\beta' X)$$

$$prob(Y = 1) = \phi(\delta_1 - \beta' X) - \phi(-\beta' X)$$

$$prob(Y = 2) = 1 - \phi(\delta_1 - \beta' X)$$

where $0 < Y1* < Y2* <...<Y*_{k-1}$ …n is the cumulative normal distribution function such that the sum total of the above probabilities is equal to one. The specification of the orderedProbit model is as follows.

Let Y_i denote the categories: No loss (Y_i=0), Presence of loss (Y_i=1), Category of loss i.e Low loss, Minimum loss, Medium loss, High loss (Y_i=2)

In this study, the post-harvest losses of maize farmers is specified as follows;

$$Y_i^{\text{loss or no loss}} = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4 X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + \mu_i$$

Where:

$Y_i^{\text{loss or no loss}}$ = 0, 1 or 2

X_1= gender

X_2= age

X_3= years of education

X_4= farm size
X_5= farming experience
X_6= household size
X_7= area of residence
X_8= post-harvest training received

RESULTS AND DISCUSSION

Descriptive Statistics of Categorized Post Harvest Losses

The loss estimates were recorded as an ordered range of percentage of quantity losses and were stored as a categorical variable. Farmers loss estimates were then grouped into four ordered ranges; minimal loss (quantitative loss between 0 and 0.99%), low loss (between 1 and 2.99%), moderate loss (between 3 to 7%), and high loss (higher than 7%). The results present the percentage of respondents reporting four loss categories in WFSP (Wisconsin Food System Partnership) processing chain. At the harvesting stage, minimum loss was reported by 47.5% of the maize farmers, low loss was observed by 21.7% of the farmers, moderate loss of was experienced by 10% of them and a high loss was experienced by 12.5% of the farmers. At the Dehusking stage, 47.5% of the farmers experienced minimum loss, 28.3% of the farmers experienced low loss, 18.3% of the farmers reported moderate loss and 5.8% of the farmers experienced high loss. At the transportation stage, 68.3% of the farmers experienced minimum loss, 21.7% of the farmers had low loss, 11.6% of the farmers observed moderate loss and 3.8% of the farmers had high losses. At the shelling stage 51.7% of the farmers reported minimum loss, 24% of the farmers had low loss, 12.5% of the farmers observed moderate loss and 10.8% of the farmers had high losses. At the storage stage, 52.2% of the farmers observed minimum loss, 28.3% of the farmers experienced low loss, 10.8% experienced moderate loss and 6.7% had high loss. At the selling stage, 46.7% of the farmers reported minimum loss, 32.5% of the farmers had low loss, 12.5% of the farmers observed moderate loss and 8.3% of the farmers had high loss. Transportation is the stage where the highest proportion (68.3%) of the respondents reported their losses to be in the 'high loss' category.

Descriptive Statistics of Categorized Post Harvest Losses

Maizeloss category	Harvesting (%)	Dehusking (%)	Transport (%)	Shelling (%)	Storage (%)	Selling (%)
Minimum loss (0-0.99%)	57 (47.5)	57 (47.5)	82 (68.3)	62 (51.7)	65 (52.2)	56 (46.7)
Low loss (1-2.99%)	26 (21.7)	34 (28.3)	26 (21.7)	29 (24)	34 (28.3)	39 (32.5)
Moderate loss (3-7%)	12 (10)	22 (18.3)	12 (11.6)	15 (12.5)	13 (10.8)	15 (12.5)
High loss (>7 %)	15 (12.5)	7 (5.8)	5 (3.8)	13 (10.8)	8 (6.7)	10 (8.3)

No response	10	-				
Number of Obs	**120**	**120**	**120**	**120**	**120**	**120**

Determinants of Post-Harvest Losses along Processing Chain

The findings indicate that the coefficient of years of education is statistically significant and in the negative direction, indicating that more educated farmers are less likely to perceive they have bigger losses during the drying, shelling, and transporting phases. Therefore, raising awareness and enhancing education will be a key policy intervention for loss reduction at all levels of the maize processing chain. The coefficient indicates that education level is significant at the 1% level of significance and is negative for drying and shelling, indicating that better educated farmers are less likely to suffer greater losses at these stages. This suggests that for every 1% gain in education, losses due to drying and shelling will decrease by 0.0309 and 0.0591 units, respectively. The coefficient of level of education is significant at 1% level of significance and positive, which suggests that losses due to transportation will increase by 0.0486 units for every 1% increase in level of education.

The coefficients of the external training obtained on postharvest losses are negative and significant for the transport, storage, and milling stages, indicating that farmers who got training on postharvest loss management are less likely to experience severe losses at these stages. The coefficients of external training at the storage and milling stages are significant at the 5% level of significance, which means that for every 5% increase in external training, the losses resulting from storage and milling will decrease by 0.0459 and 0.772 units, respectively. Transport losses will decrease by 0.4006 units for every 10% rise in external training, according to the coefficient of external training at the transport stage, which is significant at the 10% level of significance and negative. Typically, farmers that lack postharvest management training and expertise are more likely to suffer postharvest losses.

Post-harvest losses are influenced by the techniques utilized at each stage of the processing chain. Using knives, machetes, etc. during the de-husking stage is more likely to result in larger reported loss than using bare hands. When drying, using plastic sheets is more likely to result in greater loss than using tarpaulin. When compared to transportation by motorbike, transportation to markets by truck is more likely to cause greater loss. Comparing shelling with fingers or physical rubbing of maize cobs against one another, bashing cobs in sacks with sticks is more likely to result in larger loss. In comparison to keeping corn in a room in the house, silos and the use of hermetic storage bags are more likely to result in fewer loss during the storage stage. When milling, human milling is thought to be more likely to result in lesser losses than using industrial milling equipment. Additionally, selling in a local market is more likely to incur a loss than selling at the farm gate since there is a chance that a loss could happen when the product is being transported from the farm to the market.

The coefficient of farm size is seen to be significant at the 1% level of significance and positive during the drying stage. This means that drying losses will increase by 0.607 units for every 1% increase in farm size. This suggests that the yield expected from a farm will increase with farm size, increasing the amount of maize susceptible to postharvest loss at the drying stage and vice versa.

Marginal Effects of Post-Harvest Losses in Categories

Since it is consistent with the main parameter estimates for all stages of the processing chain. According to the four sets of marginal effects educated farmers are 5.64% more likely to suffer a very high loss. Marginal effects of the respondent's education level reveal that the likelihood of being in the very high loss category increases by 5.64% for every additional unit of education. With each additional farm unit, the likelihood of being in the low loss category increases by 30.7 %, the likelihood of being in the moderate loss category decreases by 4.77 %, the likelihood of being in the high loss category decreases by 13.6%, and the likelihood of being in the very high loss category decreases by 6.95 %. Farmers are 32.9 % more likely to suffer low losses during harvest than mild losses, 30.2 % less likely to suffer moderate losses, 12.8 % less likely to suffer high losses, and 11.4 % less likely to suffer very high losses.

Marginal effects of PHL in categories

Marginal effects:	**Low loss (0–1%)**	**Moderate loss (1–3%)**	**High loss (3–7%)**	**Very high loss (>7%)**
Age	−0.0035	0.0029	0.0061	0.0054
	(0.0073)	(0.0082)	(0.0079)	(0.0099)
Edu	0.0543	−0.0322	−0.0045	0.0564*
	(0.0141)	(0.0588)	(0.0052)	(0.0333)
Marital stat	0.061	−0.0022	−0.0013	−0.0085
	(0.019)	(0.0066)	(0.0016)	(0.0097)
Farm size	0.307***	−0.0477**	−0.136***	−0.0695
	(0.0212)	(0.0221)	(0.0334)	(0.0481)
Ext train	0.000	0.000	0.000	0.000
	(0.004)	(0.001)	(0.001)	(0.001)
Maize harvest (kg)	0.329***	−0.302***	−0.128**	−0.114***
	(0.126)	(0.079)	(0.057)	(0.036)

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

CONCLUSION

From the results of this study, the variables impacting postharvest losses at each node of the processing chain were identified. Using cross-sectional data from the study area, smallholder farmers' perceptions of postharvest losses in each level of maize processing chains were evaluated. Through careful estimation, the variables impacting postharvest losses at each node of the processing chain were found. The findings demonstrate that socioeconomic variables as well as the currently used postharvest techniques have an impact on physical losses following harvest at various points throughout commodity processing chains. Higher levels of education and training in post-harvest loss control are associated with lower post-harvest losses at critical stages of processing chains, according to socioeconomic characteristics. The number of years spent in school is linked to a lesser chance oflosses during the drying and shelling processes but a higher chance of loss during transportation. Farmers with postharvest loss training are less likely to experience substantial losses throughout the storage, milling and transportation processes. Farmers who are married are less likely to experience loss at the point of drying.

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Comparative Analysis Of Fish Consumption Pattern Among Households In Lagos State, Nigeria

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ABSTRACT

The study was on fish consumption among households in Lagos State. A multistage sampling technique was used to select 400 households from Lagos Island, Eti Osa, Surulere, Shomolu, Kosofe and Oshodi/Isolo Local Government Areas. A structured questionnaire was used to collect the data needed for the study. The data were analyzed using the descriptive statistics The result indicated that the study area had more male-headed households (52.5%). The average monthly expenditure on fish by household was ₦3,640 Result of the descriptive statistics further shows that a large number of consumers had preference for fresh fish (60.7%) and smoked fish (54.7%). The study recommends the improvement of the market for fish by creating value through packaging processing and storage and better storage facilities is pertinent. This can be achieved by government provision of steady power supply and agro processing industries which must be linked to production for household consumption.

Keywords: Fish, Consumption, Household, Lagos-State.

INTRODUCTION

Fish is an important component of a modern healthy diet and also a critical food source for developing countries Fish provides key macro and micro nutrients, protein and are low in saturated fat .(Lynch & Macmillan, 2017). Fish consumption has been linked to a wide array of health benefits for infants and adult including the developing foetus (Millen et al, 2015). According to Nesheim and Taktine (2007), fish can supply up to 50 percent or more of high quality protein, mineral elements(B6, B12, niacin, thiamine, riboflavin, Vitamin E) and essential fatty acid such as oleic acid and omega3 fatty acid.

The united nation food and Agriculture organization noted that world population growth has outweighed fish production due to increased fish consumption. Fish consumption per capita across the world has increased from 9.0kg in 1961 to above 20.5kg in recent times as a result of the upsurge in population growth, urbanization and demographic dynamics(FAO, 2018, Falaye & Jenyo-Oni, 2009). Fish consumption (demand) raises enormous challenges for economies. Utilization of fish varies for food and non-food purposes across countries and regions. More importantly, the utilization of fish for direct human consumption increased significantly over the years from 67 percent to 88 percent in 2016 (Vannuccini et al., 2018). Hence, the consumption pattern for fish have peculiar implications for the sub-sector in various economies.

Fish plays a vital role in feeding the world's population and contributing significantly to the dietary protein intake of hundreds of millions of the populace. In Nigeria, 50 percent of total average intake of animal protein is attributable to fish. (Liverpool-Tasie et al., 2021.The quality of the fish/seafood freshness is the prime determinant. In this regard frozen fish are treated as non-fresh, bad quality, tasteless, watery and boring (Olsen, 2001). Other attributes like price and convenience also have impact on fish consumption attitude formation. However, Olsen (2004) found price, value for money and household income not barriers to seafood consumption, while Verbeke (2005) reported that price negatively affect fish consumption attitude because of complex preparation and cooking procedure, fish is treated as an inconvenient food item (Verbeke *et al*, 2006).

Despite the importance of fish in Africa, particularly for addressing malnutrition, examination of fish demand has been limited. There are few survey-based analyses of the demand in Africa, though exceptions include: Abdulai and Aubert (2004) for Tanzania; Tambi (2001) for Cameroon; and local area studies such as Amaoet al. ,(2006) for Lagos State in 'Nigeria. Zhou and Staatz (2016) used Living Standards Measurement Study (LSMS) data from around 2012 to estimate income elasticities for fish as a general category compared with other food categories tor West Africa. Desiere et al (2018) also used LSMS and FAO data to assess current and future meat and fish consumption, in a group of countries in sub-Saharan Africa. Gen-schick et al. (2018) analysed urban Zambian fish consumption patterns of the poor strata.

Moreover, there has been little research globally on the determinants of the form in which fish is purchased. 'Traditional forms' include dried/salted, smoked, and fresh, all of which were common prior to the advent of refrigeration, and freezing. The main non-traditional product form is frozen, fish, which is thawed after purchase for use at home or in restaurants.

Fish consumption analyses have often treated fish (and 'sea food') as a homogeneous group of products and few studies differentiate either species or form. There are some exceptions: Toufique et al (2018) distinguish fish originating from capture or aquaculture. Dey et al. (2008) distinguish dried fish from other fish in Asia. In Europe and the US, Trondsen et al (2004) distinguish processed from fresh,and Verbeke et al. (2007) distinguish traditional presentation styles versus fresh. In the United States, Muhammad and Hanson (2009) distinguish fresh and frozen cat-fish- In Africa, studies of demand for different fish forms are either of a locality, or of one species, or limited product forms (Kumar et al, 2005: Jimoh et al, 2013; Dauda et al., 2016).

The African literature has not had a systematic analysis of: (i) consumption of domestically produced versus imported fish; (ii) consumption of different forms of fish, such as frozen, fresh, dried and smoked; (iii) consumption of fish over spatial categories such as agro ecological zones, and regions with different levels of development. These gaps are important for the following reasons. First, unlike Asia, food imports are among the top policy concerns in Africa (African Development Bank, 2016) due to their viewed foreign exchange burden and their competition with the domestic fish sector. In Africa, the share of imports in total apparent consumption of fish more than doubled over the four decades 1970s – 2000s, to a high of 39% by 2017. This compares to the import share (derived from FAOSTAT) in all food for 2017 of 13% (Liverpool-Tasie et al., 2020.

At the household level consumption pattern may depend on the availability of the income, price of the commodities, primary activities of the household, social structure and customs. The actual quantity of fish consumed, the price paid by consumer for 1kg of fish and other factors like education level, age, gender, household size and income affects the consumption of fish are however poorly documented, particularly in Lagos state, besides the empirical evidences emerging from few studies on fish demand at the household level which has yielded mixed result that is inconclusive and contradictory. Thus, the questions on how household consumer is still worthy of further research such as the one being undertaken in this study. Also, empirical evidences largely scanty, isolated and devoid of in depth analysis of the combined effects of socio-economic and micro economic factors on fish consumption in the context of their significance and size in Lagos state, Nigeria. This creates gap in literature.The Objectives of this study include: examine the socio-economic characteristics of the household, determine consumers' preference for fish, identify the various types and forms of fish consumed by the respondents and identify the constraints for fish consumption in the study area.

METHODOLOGY

Study Area

The study was carried out in Lagos State Nigeria. Lagos State is located in the south-western part of the Nigerian Federation. On the North and East it is bounded by Ogun State. In the West it shares boundaries with the Republic of Benin. Behind its southern borders lies the Atlantic Ocean. 22% of its 3,577 km^2 are lagoons and creeks. It lies within the latitude 6 and 24^1 and 6 31^1 N, longitude $3^0 16^1$ and $3^0 37^1$ Lagos State has 20 local Government Areas out of the 774 Local Government Areas in Nigeria. It Comprises of three senatorial district(Lagos east, Lagos west and Lagos central).It has a population of 9,013,534 as at 2006 National population census (NPC).The highest maximum temperature ever recorded in Lagos was 37.3^{o}C (99.1^{o}F) and the minimum 13.9^{o}C (57.0^{o}F) (Lagos Meteorological Organization 2012). Multi-stage sampling technique was used in selecting the respondents for the study. The first stage in the sampling procedure was the stratification of the study area into cells of high, medium and low density areas Oluwole Samuel Ojewale (2014). With respect to Lagos, areas of high population density are usually populated by low income class. This sampling technique was to ensure that each income group was adequately represented in the sample. In the second stage Lagos Island and Etiosa local government area were selected for the low density areas, while Surulere and Shomolu LGA represented the medium density areas. For the high density areas, Kosofe, and Oshodi/Isolo LGA were selected (these LGA were selected using convenience sampling).The third stage involved the selection of households via random sampling procedure. A complete list of all the households in each of the LGA was obtained from the National Population Commission Census list. A total of 400 households in these areas were randomly selected with sample size distributed proportionate to size.

RESULT AND DISCUSSION

Socio-Economic Characteristics of fish consumer household

The socio-economic characteristics analyzed include: gender, age, marital status, family size, household income, occupation and forms of fish consumed.

Table 1 Distribution of Household by their socio economics

Variable	Category	Frequency N= 400	Percentage
Gender	Male	210	52.5
	Female	190	47.5
Marital Status	Single	155	38.75
	Married	215	53.75
	Widowed	30	7.5
Age	Less than 20 years	68	17.0
	21 – 30 years	80	20.0
	31 – 40 years	88	22.0
	41 – 50years	103	25.75
	50years and Above	61	15.25
Educational Level	Informal education	68	17.0
	Primary school	88	22.0
	Adult literacy	61	15.25
	Secondary school	103	25.75
	Tertiary school	80	20.0
Family Type	Nuclear Family	198	49.5
	Extended Family	202	50.5
Family size	< 2	145	36.25

	2----5	213	53.25
	>5	42	10.5
Household Monthly Income	< ₦10,000	39	9.75
	₦10,00--₦19000	45	11.25
	₦20,000--₦29,000	66	16.5
	₦30,000-₦39,000	69	17.25
	₦40,000-₦49,000	78	19.5
	₦50,000 and above.	103	25.75
Monthly Expenditure on Fish (mean)	₦3,640		
Source of income	Salary	182	45.5
	Non-Salary	218	54.5
Occupation	Farming	50	12.5
	Civil Servant	102	30.7
	Trading	130	32.5
	Banking	70	17.5
	Artisan	53	13.25

Source: Field Survey, 2021.

Gender of the household heads is an important factor that has significant influence on the preference and consumption pattern of fish by households. The distribution of household by gender and forms of fish is presented in Table 1 and shows that although the percentage of male headed households (52.5%) are more than female headed household (47.5%), the number of female headed household is very substantial. This is in line with result of Chianu &Tsujii (2007) where 99.7% of the surveyed household were male headed. The distribution of the household by marital status is presented in Table 1. The result shows that 53.75% of the households were married while 38.75% are singles and 7.5% are widowed. This shows that there is the tendency for more purchase of fish and increased consumption by households headed by married people than singles due to expansion in family size and greater responsibilities in terms of expenditures on food items. Therefore, there is a tendency for more purchases of fish~~.~~ (Amao & Ayantoye 2014). There is a tendency for the age of the household head to affect the consumption pattern of a household and may determine to an extent the type, quality and nutrition of a given household. This in agreement with Aminu, Adebanjo and Mohammed (2016). Further results show~~s~~ that a large number of household heads (103) fell within the age group of 41-50 years and represented about 25.75% of the respondents. Age could be an important determinant in the quality and quantity of protein requirement of an individual and households (Amao et al., 2006). Education changes taste over time and usually affects consumption pattern, preference for food items and nutrition of a household. This is because consumers become aware of the nutritional value of protein rich food items like beef, eggs and fish and subsequently enhance their consumption. The distribution of household head by level of educational attainment, as presented in Table 1, shows that household heads with secondary education had the highest percentage of 25.75%. The majority of the respondents (50.5%) belong to an extended family in the study. Family size have a significant effect on the consumption pattern for fish as with other food items. As the family size increases, there is tendency for the household to consume more food generally, fish inclusive. Majority of the households in the study area (53.25%) had between 2-5 members. The literacy level of the respondents might have contributed to the relatively small household size. Education has been reported as one of the key determinants of the awareness and use of family planning measures (Babalola, Babalola & Oladimeji, 2012). Information on demographic patterns in Nigeria also shows that urban households are usually smaller than rural households (Statista Research Department, 2021). The frequency distribution of income determines the type of income distribution most prominent in the study area. Table 1 shows that the majority of the respondents fall within the low income group while those in the high income class are relatively few. Low income may affect overall fish consumption and further determine the form of fish consumed by households. Table 1 shows that majority of households sampled (218) were non salary earners, accounting for about 54.5% of total sampled respondents while (182) were salary earners, accounting for about 45.5% of total sampled respondents. A priori expectation is that the probability for salary earners to have a more planned and consistent consumption pattern than the non- salary earners is higher. This may also influence an increase in household purchasing power. However, most of the household in the study area are non-salary earners. In particular, the majority of the respondents are traders (33%). Most of the respondents spend the average monthly expenditure on fish by the household in the study area was ₦3,640.

Table 2 Distribution Of Household By Fish Consumption Pattern

Variable	Frequency N= 400	Percentage
Fish consuming Household		
Yes	842	85.5
No	58	14.5
Reason for Fish Consumption		
Taste	111	74.0
Nutritious	132	88.0
Availability	77	51.3
Affordable	70	46.7
Low in cholesterol	88	58.7
Forms of Fish Consumption		
Fresh	91	60.7
Frozen	76	50.7
Smoked	82	547
Dried	79	52.7
Types of Fish Consumed		
Clarias (Catfish)	76	50.7
Tilapia	68	45.3

Mackerel (Titus)	78	52.0
Horse mackerel (Kote)	90	60.0
Croaker	84	56.0
Hake (Panla)	106	70.7
Herrings (Shawa)	23	15.3
Argentina Silos (Ojuyobo)	50	33.3
Choice of Purchased		
Market	113	75.3
Farm	50	33.3
Road Side	98	65.3
Import	29	19.3
Fish Storage		
Yes	315	78.75
No	65	31.25
Protein Source Consumed		
Chicken	98	65.3
Egg	115	76.1
Mutton (Sheep Meat)	18	12.0
Pork (Pig Meat)	36	24.0
Turkey	73	48.7
Chevon (Goat Meat)	56	37.3
Beef	77	51.3

***Multiple Response**

Table 2 Distribution Of Household By Fish Consumption Pattern (Cont'd)

Variable	Frequency	Percentage
Reason for Consumption of Other Protein Source		
Availability	107	71.3
Relatively Cheap	8	5.3
Taste	120	80.0
Smell	84	56
Size	99	66
Appearance	51	34
Constraint		
Distance from the Market	101	67.3
Low Traded Volume of Fish	18	12.0
Rapid Fish Spoilage	104	69.3
High price of fish	96	64.0
Low Level of Consumer Income	62	41.3
Religious Belief	38	25.3
Health Reasons	41	27.3

***Multiple Response**

Source: Computed from Field Survey (2021)

The result in Table 2 reveals that majority of households sampled (342), accounting for about 85.5% of total sampled respondents, consume fish as their major protein source. This suggests that there are more fish consuming household in the study area. Also, majority of households sampled (88.0%) gave nutrition as the major reason for consuming fish. Other reasons given include taste (74.0%), low cholesterol (58.7%), availability (51.3%) and affordable (46.7%). Increasing fish availability will likely increase fish consumption among the study population? More than half of the respondents (60.7%) prefer fresh fish to frozen, smoked or dried fish. About 50.7% of households indicated their preference for frozen fish, while 54.7% and 52.7% of the households sampled had preference for smoked and dried fish respectively. The most preferred forms of fish by households are further presented in Table 2. A large proportion of households (106) accounting for about 70.7% of sampled households consumed Hake (Panla) compared with any other type of fish, 52% had preference for Mackerel (Titus) while about 60% consumed Horse Mackerel (Kote). Some 50.7% of households preferred Clarias (catfish), 56% of households had preference for Croaker, and 45.3% preferred Tilapia. The result in Table 2 reveal that majority of the household sampled (70.7%) purchase their fish from the open wet markets. Furthermore, majority of households sampled (315) fish consuming household accounting for about 78.75% of total sampled respondents store their fish. This corroborates with their high preference for fresh fish. From Table 2, Majority of the respondents (76.7%) indicated that they consume egg as alternative protein source to fish. This shows that egg is a close substitute for fish in the study area. The relatively low price of egg may also be responsible for this reference. The result in Table 2 shows that a higher proportion (80%) of the sampled household chooses availability as the reason for consumption of other protein source. The result in Table 2 reveals that majority of households sampled (104) fish consuming household accounting for about 67.3% of total sampled respondents gave rapid fish spoilage as constraint because they consume fresh fish and preserve by refrigerating or sun drying. Rapid spoilage of fish could be as a result of poor power supply to power the refrigerator used for preservation of the fish. Some 101 sampled fish consuming household accounting for 67.3% gave distance from the market as their challenge, other constraint include high price of fish (64%). High prices of the product could be as a result of high transportation, high cost of production and high cost of preservation. Low level of consumer income (41.3%), health reasons (27.3), religious belief (25.3%) and low traded volume (12%).

CONCLUSION AND RECOMMENDATION

This study examines fish consumption pattern among consuming households in Lagos metropolis with a view to analyzing the trends of fish consumption, consumers' preference for fish and the functional relationship between the quantity of fish consumed and selected variables. The variables examined include income of the household, taste, price of fish, occupation, household size, level of education and age of the household head which were found to influence households fish consumption expenditure. The food and fish consumption expenditure analysis of households revealed that the average monthly expenditure on food and fish tends to increase with increase in household income, but the percentage of income spent on food and fish decreases with increase in the income of the household in accordance with Engels law. For the average monthly expenditure on fish by household size, it was observed that the average monthly expenditure on fish increases as the household size increases. This was found to be true for the average monthly expenditure on fish by the age of the household head. As the age of the household head increases, their average monthly expenditure on fish also increase. Fresh fish is the highest form of fish in the consumer market, whereas smoked fish is the lowest priced. As the income of the consumers increases, they buy only a little more smoked and frozen fish because most smoked fish consumed in the metropolis are perceived to be of low quality. Wealthier consumers tend to buy more of fresh fish and dried fish (such as stock fish) which consumer perceived to be of better quality in terms of nutrition and safety. The dried and fresh forms of fish are substitute mainly because the most common type of fresh fish in the area (the cat fish) is also the dried fish in the market. The socio economics characteristics reveal that the consumers are not poor. These categories of the population are mostly educated and well exposed and are well within their regular intake of fish protein. However, there is need for further research to disaggregate consumption groups and account for the fish protein intake level in the study area. There is a need therefore to increase domestic fish supply in the country and ensure fish supplies to consumers at affordable prices in all market in the metropolis. Facilitation of supply of fresh and frozen fish is recommended because it attracts higher preference especially in the open market. Finally, there is a need to create consumer awareness of nutrition information through education and media promotion.

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Sub-Theme B:

Crop production, improvement strategies and seed technology, Forest resources, Ecotourism, Wildlife and environmental management issues and strategies and Soil and water resources conservation and management

Assessment of tomato fields for *Fusarium* wilt (*Fusarium oxysporum f. sp. lycopersici*) pathogen in Yamaltdu Deba local government, Gombe State, Nigeria

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ABSTRACT

An experiment was conducted at the screenhouse of Federal College of Horticulture, Dadin-Kowa Gombe State, Nigeria during 2021rainy season. The aim of the experiment was to evaluate farm soils of tomato fields for Fusarium wilt pathogen. The treatments consisted of soil samples collected from 6 different locations in the study area namely;- Dadin-Kowa, Deba, Gwani, Kwadon, Shinga and Zambuk which served as inocula source. . Five grams of each soil sample collected was dissolved in 10ml of distilled water and stirred thoroughly to obtain inoculum. This was sprayed on the transplanted seedlings to the point of runoff while the control was sprayed with water. .. Data were collected on percentage disease incidence, severity of Fusarium wilt infection, yield and percentage yield loss per plant. Data collected were subjected to analysis of variance and means were separated at $p<0.05$ using SNK with Genstatth Edition statistical software. The result revealed significant differences in Fusarium willt incidence, severity, yield and percentage yield loss among the locations where samples were collected. It can be concluded that the farms where tomato is cultivated in Yamaltu Deba local government were infected with Fusarium wilt pathogen. There was variation in the intensity of infection and consequent yield loss which ranged from 19-60%. Tomato farms of Dadin-Kowa, Deba and Kwadon were more severely infected. The yield loss was more pronounced in Dadin-Kowa and Deba. High yield loss in Shinga could be due to other soil-borne pathogens. Fusarium wilt pathogen is not a serious disease of tomato in Zambuk.

Keywords. Incidence, severity, Fusarium wilt and tomato

INTRODUCTION

Tomato (*Solanum lycopersicon* L.) is one of the most popular and widely grown vegetable in the world. It is one of the important food and cash crop for many low-income farmers in the tropical countries. It is very rich in vitamin C and minerals, especially phosphorus, potassium and calcium (Taylor, 1987). This reference is too old). Diseases are major limiting factor for vegetables, causing serious yield reduction and leading to severe economic losses. The average global crop losses caused by plant diseases is about 12.8% (). Losses attributed to diseases on tomato alone was estimated be 21.8% (Melese and Samul, 2018). Several diseases **affect** tomato during its growing season. Fungi are the most common cause of infectious plant diseases and can be very destructive. One of the most common fungal diseases that infect tomatoes is *Fusarium* wilt (Rangaswamy 1999).

Fusarium. oxysporum (causative organism of *Fusarium* wilt) is a widespread soil-borne fungal pathogen. *Fusarium* wilt is cosmopoliatan and there is currently no resistant tomato variety to the disease. The pathogen persists for many years in the soil without a host (Rangaswamy, 1999). Most infections originate from the fungus associated with infected tomato debris. Root knot nematode infection makes *Fusarium* wilt-resistant varieties more susceptible to the fungus because of physiological changes in the root. Disease development is favoured by warm temperatures (27–28 °C), dry weather, and acidic soil (pH 5–5.6). Succulent tomato plants exposed to fertilization with ammonium nitrate are especially susceptible to the disease. The fungus can be disseminated by infected seed or by transplants grown in infected soil. The fungus can be introduced into a field on contaminated equipment, stakes, packing crates or shoes. Soil particles from infected fields may be blown into disease-free fields.

The initial symptoms are yellowing of the foliage, beginning with the lower leaves and progressing upwards. Yellowing often begins on one side of the vine. Infected leaves later show downward curling, followed by browning and drying. The top of the vine wilts during the day and recovers at night, but wilting becomes progressively worse until the entire vine is permanently wilted. Vascular browning can be seen in infected stems and large leaf petioles (Brammall and Higgins, 1988). Affected plants and their root systems are stunted. The degree of stunting depends upon the time of root infection. Plants infected early are more severely stunted than plants infected at a later stage. Soil-borne and foliar fungal diseases are a major limiting factor for tomato production. Yamaltu-Deba local government area of Gombe State Nigeria was well known for massive dry season tomato production in previous years but nowadays the production is very low. Abdulkadir et al. (2019) reported that among the major factors limiting dry season tomato production in the area, pests and diseases are the most serious. Hence a study to investigate tomato field for soil-borne pathogen, especially, *Fusarium* wilt cannot be over emphasized. The research was aimed to determine the incidenceand severity of *Fusarium* wilt pathogen in tomato farms at different locations in Yamultu Deba local government of Gombe state and ascertain yield loss of tomato due to the pathogen.

MATERIALS AND METHODS

The experiment was conducted in the rainy season of 2021 at the screen house nursery unit of Research and Training Farm of Federal College of Horticulture, Dadin-Kowa, Gombe State, Nigeria. The experiment consisted of 6 soil samples collected from 6 different tomato farms within Yamaltu Deba Local Government Area of Gombe State.: - Dadin-Kowa, Deba, Gwani, Kwadon, Shinga, and Zambuk. The design of the experiment was Completely

Randomized Design (CRD) with 4 replications. To prepare the medium, the top soil was sterilized at a temperature of 90°c for 3 hours. This is to ensure free germ medium so that the only source of the pathogen was the inoculum. The sterilized medium was used to raise the seedlings in a plug 2 seed per chamber and later thinned to one plant per stand. The seedlings were transplanted at 3 weeks after sowing into plastic containers containing the sterilized soil. A spacing of 5cm was left at the top of the container to promote water retention. Watering and weeding were carried out to ensure moisture stress and weed free conditions, respectively. NPK 15:15:15 fertilizer was applied at the rate of 450kg/ha. The soil samples were collected using W sampling method from 3 tomato cultivated soil in each location, bulked to form a single sample and labeled accordingly. To prepare the inoculum, 5g of each soil sample collected was dissolved in 10ml of distilled water and stirred thoroughly**.** The inocula prepared were sprayed on the transplanted seedlings untilto the point of runoff using hand sprayer at 2 weeks after transplanting. The control plot was sprayed with water. Thereafter, the seedlings were covered with polythene bags for 24 hours to promote ideal humidity for infection.

Data were collected on the following parameters at 2, 4, 6 and 8 Weeks after Inoculation (WAI)**:**

Disease Incidence (DI): This was calculated using the formula below:-

$$DI = \frac{\text{Number of plants infected}}{Total\ number\ plants} \text{ x } 100$$

Disease severity: The plants were scored using the rating scale of 1-5 modified from Owolade *et al*, (2006), as follows:-1= no symptoms. 2= Up to 20%, 3= 21 to 40%, 4= 41-60%, 5= > than 61% . **The** fruits were harvested at maturity from each experimental unit, weighed and the average taken and expressed as yield per plant in kg. Percentage yield loss was calculated as the ratio of the difference between yield of the control and yield of treatment multiplied by 100. The data collected were subjected to analysis of variance (ANOVA) using SNK Genstatth Edition statistical software and means were separated using SNK at 5% level of probability.

RESULTS AND DISCUSSION

The result of percentage incidence is presented in Table 1. There was nosignificant difference between the locations at 2WAI. However, Deba, Kwadon and Shinga recorded higher incidence than the grand mean. At 4WAI, Shinga recorded the highest percentage incidence but at par with all other locations, except Zambuk. The control was significantly lower. At 6WAI, Deba had the highest disease incidence but this was at par with all other locations, except Dadin-Kowa which in turn was statistically similar with the other locations except Shinga and Dadin-Kowa. At 8WAI, Kwadon had the highest *Fuasrium* wilt incidence but at par with all other locations except Dadin-Kowa. Zambuk recorded the lowest incidence among the locations but at par with Dadin-Kowa while control is significantly lower. The intensity of *Fusarium* wilt pathogen among the locations differed at different periods after inoculation. This suggests variation for managing the disease based on locations. Abdulkadir (1998) also reported different time of intensity of disease incidence among locations on anthracnose pathogen of sorghum. It worth to note that the control (un-inoculated) recorded lower *Fusarium* wilt incidence (0.4-1.4%). This could be attributed to the inability of the spore to be blown by air and infect the plants in the control plots. Scarlett *et al*., 2015 identified both micro and macroconidia of *Fusarium oxysporum* f.sp *cucumerium* as air-borne.

The result of severity of *Furasrium* wilt infection as indicated in Table 2. It revealed non-significant differences among the locations evaluated at 2WAI. However, Kwadon and Shinga registered severe infection more than the grand mean. At 4 WAI, there was a significant difference (P<0.05) in the severity of *Fusarium* wilt among the treatments. The control had lower severity while there was no significant difference among the locations. At 6WAI, there was a significant difference of severity of *Fusarium* wilt infection on tomato among the locations. Deba recorded the highest severity which was statistically similar to Dadin-Kowa and also at par with all locations except Shinga which in turn was at par with Gwani, Kwadon and Zabuk. The control treatment had the lowest severity

Table 1: Percentage Incidence of *Fusarium* Wilt Pathogen on Tomato

Treatments **Source of inoculation**	**2WAI**	**4WAI**	**6WAI**	**8WAI**
Dadin-Kowa	5.4	16.6ab	23.5b	34.9bc
Deba	9.4	16.6ab	30.3a	47.2ab
Gwani	3.1	12.3b	25.1ab	44.7ab
Kwadon	9.0	16.8ab	25.7ab	50.0a
Shinga	9.1	21.6a	29.6a	43.1ab
Zambuk	2.5	10.9b	25.3ab	28.3c
Control	0.4	0.6c	0.9c	1.4d
Grand mean	**5.6**	13.6	22.9	35.7
p<F	NS	**	**	**
SE±	3.22	4.0	2.56	5.72

Means followed with the same letter in a column are not significantly different using SNK at 5% level of probability.

of *Fusarium* wilt infection. Similarly, there was a significant difference (P<0.05) in severity of *Fusarium* wilt infection at 8WAT where Kwadon recorded the highest severity but it was at par with all other treatments except Zambuk and the control. The ocntrol had significantly lower severity of *Fusarium* wilt infection, followed by Shinga which was at par with all other locations except Kwadon. Kwadon was found to register both the highest incidence and severity of *Fusarium* wilt at the end of the sampling period (8WAT).

The result of fruit yield as shown in Table3 indicated that the control produced the highest fruit yield but it was at par with Zambuk which in turn was statistically similar with Deba, Gwani and Kwadon. Dadin-Kowa recorded the lowest fruit yield per plant but it was at par with Shinga which was also at par with Deba, Gwani and Kwadon. These results confirmed the report by Melese and Samul (2018) that strains of the pathogen, climate, and/or soil characteristics present in each location impact infection or resistance of *Fusarium* wilt pathogen. The result of percentage fruit yield loss due to infection of *Fusarium* milt pathogen differed significantly ($p<0.01$) where Dadin-Kowa was significantly higher, followed by Shinga, Deba, Gwani, Kwadon and Zambuk, respectively. Several authors reported yield loss due to *Fusarium* wilt infection within the range found in this research. Fravel *et al*. (2005) reported that *Fusarium* wilt caused caused yield reduction of up to 25%. Bowyer (1999) also reported that *Fusarium* wilt caused 25% yield loss in western countries and almost 50% in the developing countries. *Fusarium. oxysporum* f. sp. *lycopersici* is highly destructive both in greenhouses and field grown tomatoes, yirld loss of 10-50% (Mao *et al*., 1998). In Tamil Nadu, wilt incidence up to 25% was reported (Kapoor, 1988) and yield loss of 10-50% was reported by Lukyanenko (1991). A yield loss of up to 45% was recorded in northern and Southern states of India (Kalaivani, 2005). Kirankumar *et al*. (2008) reported 30-40 % yield loss in tomato due to *Fusarium* wilt.

Table 2: Severity of *Fusarium* Wilt Pathogen on Tomato

Treatments **Source of inoculation**	**2WAI**	**4WAI**	**6WAI**	**8WAI**
Dadin-Kowa	0.3	1.3a	2.3a	3.5ab
Deba	0.4	1.4a	2.5a	3.5ab
Gwani	0.4	1.3a	2.1ab	3.9ab
Kwadon	0.7	1.8a	2.2ab	4.3a
Shinga	0.5	1.5a	1.6b	2.9b
Zambuk	0.3	1.7a	2.0ab	3.1b
Control	0.1	0.2b	0.4c	0.9c
Grand mean	**0.4**	**1.3**	**1.9**	**3.1**
p<F	NS	*	**	**
SE±	0.17	0.36	0.28	0.47

Means followed with the same letter in a column are not significantly different using SNK at 5% level of probability.

Table 3: Yield and Percentage Yield Loss of Tomato due to *Fusarium* Wilt Pathogen

Treatments **Source of Inoculation**	Yield (Kg/plant)	Yield loss (%)
Dadin-Kowa	0.29d	59.7a
Deba	0.43bcd	40.2c
Gwani	0.46bcd	36.3d
Kwadon	0.53abc	26.4e
Shinga	0.33cd	54.2b
Zambuk	0.58ab	19.3f
Control	0.72a	-
Grand mean	**0.48**	**39.3**
p<F	*	**
SE±	0.09	0.05

Means followed with the same letter in a column are not significantly different using SNK at $p<0.05$

CONCLUSION AND RECOMMENDATION

Fusarium wilt pathogen was recorded in all tomato farms in Yamaltu Deba local government. However, there is variation in the intensity of infection and consequent yield loss. Tomato farms of Dadin-Kowa, Deba and Kwadon were more severely infected. Yield loss due to *Fusarium* wilt is more pronounced in Dadin-Kowa and Shinga. *Fusarium* wilt pathogen is not a serious problem of tomato in Zambuk. To boost production of tomato in Yamaltu Local Government, *Fusarium* wilt resistance tomato varieties should be cultivated in Dadin-Kowa, Deba and Kwadon. Tomato farms in Shinga and environs should be investigated for other soil-borne pathogens.

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Organic and mineral fertilizer effects on growth parameters of cocoyam in Abraka, Delta State

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ABSTRACT

An experiment was set up to examine the performance of cocoyam (Colocasia esculenta L. Schott) to varying levels of cow dung and potassium fertilizer in 2018 and 2019 cropping seasons under field conditions at the Research Farm of the Agricultural Science Education Unit of the Delta State University, Abraka, Nigeria. The experiment was a 4 × 2 factorial arrangement in a randomized complete block design with three replications. The treatments were four levels each 6 of cow dung (0, 10, 20 and 30 t ha^{-1}) and potassium fertilizer (0, 20, 40 and 60 kg K_2O ha^{-1}). Application of cow dung at the highest rate of 30 t ha^{-1} significantly ($P < 0.05$) enhanced plant height, leaf area index, number of suckers and yield of cocoyam (23.6 t ha^{-1}) in both cropping seasons relative to the lower rates and the control. In general, potassium fertilizer application did not exert much influence on growth parameters of cocoyam as significant effect was observed in both cropping seasons. The results of this study have shown the effectiveness of cow dung in improving the growth performance of cocoyam which is a reliable indicator of yield.

Keywords: Organic and mineral Fertilizer, Cocoyam, Growth Parameters

INTRODUCTION

Cocoyam (*Colocosiaesculentus L.*) is one of the major root tubers produced in large quantity in Nigeria, which is the highest producer in the world. Nigeria produces 40% of the total world output, while Ghana which comes behind produces 31% (Nwite *et al.*, 2020). According to Eke-okoro *et al*. (2005), cocoyam is classified into 6 cultivars namely Coco-India (NCY004), Green Ede ofe (NCY005), Purple Ede ofe (NCY006), Giant Ede ofe (NCY007), Ukpong (NCY008), and Ghana (NCY009). Cocoyam contains easily digestible starch as well as vitamin C, riboflavin and thiamine. The leaves are also edible and used for delicacies in many families in Igbo land and some parts of Delta and Edo States. Cocoyam is known to have so many therapeutic values in the treating of potentially allergic infants and persons with gastro-intestinal disorder and for diabetic patients (Eke-Okoro *et al.*, 2005).

The crop requires 2-4 months of rainfall per annum, average temperature of about 21^{o}C and it grows on a wide range of soils.

The current level of cocoyam production in Nigeria estimated at 15 million metric tonnes in 2016 (FAO, 2017) is grossly inadequate to satisfy the increasing demand for the crop as alternative food crop (Shiyam et al., 2017). This low level of cocoyam production is attributed to increasing decline in soil fertility levels and lack of soil management practices for continuous cocoyam cultivation (Agbede & Adekiya, 2016). The use of organic and mineral fertilizers are the two major and common ways in which soils are managed since the extinction of shifting cultivation as well as reduction in bush fallow periods (Makinde et al., 2011).

In recent years, however, the focus on soil fertility has shifted towards the combined application of organic and inorganic fertilizers for judicious management of resources and soil conservation under intensive cropping (Fening et al., 2011). Sole use of organic manures to sustain cropping has been reported inadequate especially in the year of application (Patel et al., 2000). They are required in rather large quantities to meet crops' nutrient supply because of their relatively low nutrient content (Palm et al., 1997). Efficient use of chemical fertilizer and organic manures in crop production are measures that has been shown to enhance and increase plant growth and nutrient uptake, which forms the basis for higher crop yield (Anjorin, 2013). The objective of this study was to determine the organic and mineral fertilizer effects on growth parameters of cocoyam

MATERIALS AND METHODS

The location of the field experiment was the Research Farm of the Agricultural Science Education Unit of the Delta State University, Abraka, Nigeria (latitude 50 46'N and longitude 60 5'E). The area has a bimodal rainfall with annual rainfall of 2323mm and a mean temperature of 26.70C. The area is characterized as a humid rainforest zone and the soil is sandy loam. The total annual rainfalls for 2018 and 2019 were 1902.8 and 2210.0 mm, respectively while the total rainfalls during the period of experimentation in 2018 and 2019 were 1775.6 mm and 2009.0 mm, respectively.

The cocoyam (*Colocasia esculenta*var NCe001) cormels used in this study were sourced from National Root Crops Research Institute, Umudike, Abia State. The cow dung was obtained from local cattle ranches in Abraka, Delta State while the potassium fertilizer (60 % muriate of potash, K2O) was obtained from the fertilizer unit of Delta State Ministry of Agriculture, Asaba. Composite sample of the cowdung was air dried, crushed, sieved and then analyzed in the laboratory for its nutrient compositions.

The experiment was a 4 × 2 factorial arrangement in a randomized complete block design and replicated three times. The treatments comprised four rates each of cow dung (0, 10, 20 and 30 t ha^{-1}) and potassium fertilizer (0, 20, 40 and 60 kg K_2O ha^{-1}). A total of sixteen treatment combinations and three replications were used. The cow dung was incorporated into the soils of the experimental plots in a single application based on the treatment combinations, at two weeks before planting to allow decomposition while the potassium fertilizer was applied to the cocoyam stands according to treatment allocation at 3 weeks after planting (WAP) using band placement method. One cormel (1.5 cm) was planted per hole at a depth of 15 cm and at a spacing of 0.5 m x 1.0m resulting to about twenty-four plants per plot and a total of about 20,000 plants per hectare. All plots were kept weed free by manual weeding.

Five cocoyam plants were randomly selected from each of the net plots, tagged and then used for the determination of plant height (cm), number of leaves and leaf area index (LAI) at 1, 2 and 3 months after planting (MAP).

The leaf area was determined using the formula of Biradar et al. (1978) as:

Leaf Area of Cocoyam = 0.917 (LW).

Where L and W are length and width of the cocoyam leaf. The leaf area index was then calculated by dividing the total leaf area by the area occupied by the plant (Biradar et al., 1978). Number of suckers and number of corms were counted. Mean values of Leaf Area of Cocoyam = 0.917 (LW). Where L and W are length and width of the cocoyam leaf. The leaf area index was then calculated by dividing the total leaf area by the area occupied by the plant (Biradar et al., 1978).

Soil sample analysis

The analysis revealed that the cowdung used in this study is composed of 2.54, 1.34, 1.16, 1.56, 0.46 and 50.70%, N, P, K, Ca, Mg and organic matter, respectively in 2018 and 2.24, 1.67, 0.65, 2.80, 0.61 and 30.76%, N, P, K, Ca, Mg and organic matter, respectively in 2019.

Table 1:Main effects of cow dung and potassium fertilizer on plant height (cm) of cocoyam at 1, 2 and 3 MAP in 2018 and 2019

Treatment	**Months after planting (MAP)**					
	1	2	3	1	2	3
		2018			2019	
Cow dung (t ha-^{1})						
0	14.6	33.8	50.1	19.3	37.3	46.9
10	14.5	40.8	61.5	22.6	43.3	56.2
20	13.1	40.0	67.6	19.4	40.3	58.9
30	13.1	40.2	69.9	20.4	39.7	60.6
Mean	13.8	38.7	62.3	20.4	40.2	55.7
LSD (0.05)	NS	5.1	4.0	2.2	2.5	4.3
Potassium (kg K2O ha^{-1})						
0	14.0	38.3	60.0	18.9	34.5	51.3
20	14.0	38.8	62.6	20.1	40.4	55.7
40	14.0	40.0	65.4	20.5	41.7	56.2
60	13.7	37.8	61.1	21.8	42.0	59.4
Mean	13.9	38.7	62.3	20.3	39.7	55.7
LSD (0.05)	NS	NS	4.0	NS	2.5	4.3
C x K	NS	NS	NS	NS	NS	NS

NS = not significant.

In 2018 cropping season, differences in plant height due to application of cow dung were significant ($P< 0.05$) at 2 and 3 MAP (Table 1). All cases of cow dung application significantly increased plant height of cocoyam compared to the control at 2 MAP. However, at 3 MAP, incremental application of cow dung up to 20 t ha^{-1} significantly increased plant height. In 2019, cocoyam plant height increased with application of cow dung at 10 t ha^{-1}, above which significant reductions in height occurred at 1 and 2 MAP. At 3 MAP, plant height increased at the highest rate of 30 t ha^{-1} compared to the lower rate of 10 t ha^{-1} or no application in both seasons.

At 3 MAP in 2018 cropping season, application of potassium at 40 kg K_2O ha^{-1} increased significantly cocoyam plant height than no potassium application (Table 1). On the other hand, at 2 and 3 MAP in 2019, application of potassium at 20 kg K_2O ha^{-1} resulted in higher plant height than the control. All cases of applied potassium produced similar plant height values.

Table 2: Main effects of cow dung and potassium fertilizer on leaf area index (LAI) at 1, 2 and 3 MAP in 2018 and 2019.

Treatment	Months after planting (MAP)					
	1	2	3	1	2	3
		2018			2019	
Cow dung (t ha-^{1})						
0	0.15	0.77	1.87	0.25	0.79	2.02
10	0.19	1.19	3.07	0.37	1.24	3.02
20	0.13	1.22	3.60	0.30	1.21	3.28
30	0.15	1.23	3.80	0.30	1.21	3.20
Mean	0.16	1.10	3.09	0.31	1.11	2.88
LSD (0.05)	NS	0.26	0.45	NS	0.38	0.62
Potassium (kg K2O ha^{-1})						
0	0.15	1.09	2.90	0.25	0.90	2.23
20	0.16	1.12	3.04	0.31	1.14	2.80
40	0.14	1.12	3.18	0.33	1.21	3.02
60	0.16	1.08	3.26	0.33	1.20	3.48
Mean	0.15	1.10	3.10	0.31	1.11	2.88
LSD (0.05)	NS	NS	NS	NS	NS	0.62
C x K	NS	NS	NS	NS	NS	NS

NS = not significant.

In both years, application of cow dung had no effect on LAI at 1 MAP but effect was more apparent at 2 and 3 MAP (Table 2). Application of cow dung at different rates resulted in significant ($P < 0.05$) increase in LAI relative to the control at 2 MAP in 2018 and at 2 and 3 MAP in 2018. LAI increased steadily with plant age. Application of potassium produced significant effects on cocoyam LAI at 3 MAP in 2019 (Table 2). Application of potassium at 20 or 40 kg K_2O ha^{-1} resulted in significantly ($P < 0.05$) higher LAI than no application while application of the higher rate of 60 kg K_2O ha^{-1} recorded higher LAI value than the lower rate of 20 kg K_2O ha^{-1}.

DISCUSSION

In general, application of cow dung resulted in increase in cocoyam plant height, the number of leaves produced per plant, LAI and number of suckers produced per cocoyam stand especially at 2 and 3 MAP. The higher growth following cow dung application would be attributed to the probable effects of the manure in improving soil physical, chemical and biological properties (Balemi, 2012; Khalid et al., 2014), which are important for crop performance.

The effects of cow dung on cocoyam appeared more pronounced later in crop growth at 2 MAP, due to the slow release of nutrients by the manure. This result is consistent with the findings of Miyasaka et al. (2001) who attributed the enhanced growth parameters and yield response of the crop to organic amendment to slow release of nutrients by the organic manures, which tied the crop over the long duration of its growth.

CONCLUSION

This study showed that both cowdung and potassium fertilizer improved growth parameters of cocoyam with cow dung having a better improvement than potassium fertilizer especially the application 30 t ha^{-1} cow dung.

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Growth and yield performance of bambara groundnut (*vigna subterranea* (l.) verdc) sprayed with brassinolide micronutrient growth regulator at different growth stages in Calabar, Nigeria

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ABSTRACT

Growth and yield performance of Bambara groundnut treated with brassinolide at different growth stages was evaluated in the early cropping season of 2015 at the University of Calabar Crop Teaching and Research Farm, Calabar (4.5 – 5.2^o N and 5.3^o E; about 39 meters above sea level) grown under screenhouse and field conditions in the Southern Cross River high rainforest zone of Nigeria. The treatments were application of brassinolide at the seedling, vegetative and flowering growth stages of Bambara groundnut corresponding to 3, 6 and 9 WAP, while the control plants were not sprayed. Results obtained indicated that plants treated at 3 WAP were significantly (P = 0.05) superior to plants in other treatments, irrespective of the environmental conditions though field plants were better than those in the screenhouse. At this growth stage, field plants were tallest (82.20 cm) with more leaves/plant (463) and highest LAI (0.680), whereas the screenhouse plants had longer petioles and wider canopy spread (68.9 cm) and attained flowering earlier in 48.10 DAP. Screenhouse plants produced few large seeds (10.8 mm) while field plants produced more (9.60) large (13.48 mm long) pods, high seed weight (11.36 g/plant), high dry matter (34.04 t /ha) and highest seed yield (1.92 t/ha). Spraying Bambara groundnut at 3 WAP was more favourable and is therefore recommended for increased productivity of the crop under field conditons in the humid environment.

INTRODUCTION

Bambara groundnut also known as Bambara nut (*Vigna subterranea* (L.) Verde; *syn Voandzeia mbtermnean* Thousars) is an annual crop and an important member of the family *Fabaceae*. The crop has different local names according to the tribes in the various areas of production and in Nigeria the crop is known among the Yoruba as 'Epa- Roro' while the Ibos call it 'Okpa' and the Hausas call it 'Kwaruru' or 'Gurjiya' (Bamshaiye *et al.*, 2011; Mabhaudhi *et al*. 2018). Bambara nut seeds are nutritious containing high amounts of protein (17 – 27 %), making it relevant to pro-poor households that can not afford the expensive animal proteins (Ndidi *et al.*,2014; Murevani-hema and Jideani, 2013).

Bambara nut has great socioeconomic impact and consumption in the semi-arid Africa where the crop is mostly grown as the third-ranking and most important grain legume crop after groundnut *(Arachis hypogaea*) and *cowpea Vigna unguiculata*) (Rowland, 1993). It is a strong and extremely adaptable plant that is well tolerated to marginal soils and hot dry climate where annual rainfall is below 500 mm and conditions are too dry for the successful cultivation of some crops like maize, groundnut and even sorghum (Rowland, 1993; Azam-Ali *et al*, 2001; Mabhaudhi *et al*., 2018). The crop also exhibits high tolerance to pests and diseases, and can be produced easily with minimal inputs, making it a suitable food security crop for the peasants in moisture-deficient areas (Ntundu *et al.,* 2006).

The cultivation of Bambara nut is being explored in the humid areas outside its traditional home in the Savannah environment due to increased demand as a food crop.

In the rainforest zone, research on foliar fertilizer application is not common due to heavy rainfall compared to the savanna areas. The effectiveness of foliar plant nutrients depends on optimum absorption of the nutrients which depends on the growth stage of the crop as well as the prevailing weather conditions during the period of application. The focus of this trial was therefore to determine the best crop growth stage to maximize the effectiveness of brassinolide, a foliar micronutrient complex under field or screenhouse conditions for optimal performance of Bambara nut in the humid agro-ecological environment.

MATERIALS AND METHODS

2.1 Experimental Site

Screen house and field experiments on bambara groundnut were conducted at the University of Calabar during the 2015 late cropping season (August - December). Calabar is located in the southeastern rainforest agro-ecological zone of Nigeria on Latitude 04° - 57'N and Longitude 08° - 19'E, 37 m above sea level. The area has a bimodal annual rainfall distribution that ranges from 3,000 mm to 3,500 mm with mean minimum and maximum temperatures of 27 °C and 35 °C, respectively and relative humidity of between 75 and 88 % (Effiong, 2011). The soil at the site was sandy with 73, 16 and 11 % sand, silt and clay respectively and ECEC 7.14 cmol/kg.

2.2 The Screenhouse Experiment

The screenhouse experiment was done using medium size plastic buckets with brim circumference of 96 cm wide, bottom circumference of 73cm and depth of 32 cm. The buckets were perforated at the bottom and filled with 6.5 kg top soil collected from the site of the field experiment, leaving about 5cm to the brim of the buckets.

The cream coloured Bambara groundnut landrace (Black eye) obtained from the Department of Crop Science, University of Agriculture, Makurdi Benue State, Nigeria was used for the experiment. This landrace consistently had a higher seed yield than other landraces in the previous trials in the area (Shiyam and Bello, 2012; Shiyam *et al*., 2016). Two seeds were sown in each bucket and thinned to one per bucket one week after emergence. The buckets were watered adequately with twenty liters of tap water and left overnight before planting the following day. A group of six buckets arranged in three rows of two buckets each constituted a unit plot in the screen house experiment and the middle row was used for sampling. Watering with twenty-five liters of water every seven days was carried out to prevent moisture stress since the experiment was not exposed to natural rainfall.

2.3 The Field Experiment

The field experiment which ran concurrently with the screenhouse was sited at the Crop Science Research Farm. The site had been under intensive cultivation for some years and the vegetation was a mixture of grasses and broad leaf weeds.

A total plot size measuring 14.0 m x 11.5 m (161 m^2) and was used for the field experiment. The vegetation was manually cleared with a machete and the debris packed. The land was then tilled manually using a spade after which three blocks were mapped out and four unit plots measuring 2 m x 3 m (6.0 m^2) within the blocks with alley ways of 1.0 m wide demarcated. There were twelve experimental plots in all.

Before ploughing, composite soil samples for pre-planting routine soil analysis were obtained from the experimental site by random soil sampling technique. Sampling was done using soil auger at 0 - 30 cm depth. Composite samples were also taken for post-harvest soil analysis. The composite samples were air-dried in the Soil Science Laboratory. The dried soil was crushed in a mortar using a pestle and sieved through a 2.5 mm mesh sieve to produce the final sample used to analyze for physico-chemical properties (Udo *et al.* 2009). All buckets and experimental plots were maintained weed-free throughout the duration of the experiment. Weeds were removed manually by hand-pulling in the buckets and by using hand-held hoes in the field.

2.4 Treatments and Experimental Design

There were four treatments comprising the control where brassinolide was not applied and spraying at different growth stages namely: spraying at the seedling, vegetative, and flowering stages which corresponded to 3, 6 and 9 weeks after sowing (WAS), respectively. Treatments were laid out in randomized complete block design replicated three times to give twelve experimental units.

2.5 Establishment of Experimental Plots

Clean healthy seeds were sown at 30 cm x 30 cm spacing, two seeds per hole and later thinned to one plant per stand one week after emergence, giving a population of 111,111 plants per hectare. Four tagged plants in the net plot at centre of each plot constituted the sample population.

2.6 Mixing and Application of Brassinolide

A solution of brassinolide micronutrient fertilizer containing Zinc, Manganese, Boron, Ferrum (Fe), Molybdenum and Copper was prepared and applied according to the manufacturer's specification. A spray solution was made by dissolving 12.5g of the nutrient in 10 litres of clean tap water. Spraying of both field and screenhouse plants was done between 8 am and 9 am each time using a knapsack sprayer. Spraying was done in such a way that sprayed plants were completely drenched.

2.7 Maintenance of Experimental Plots

The first weeding was carried out manually at 2 WAP and subsequently at two weeks intervals in the screenhouse and field.

3 Data collection and Analysis.

Data collection on growth performance was done at 15 WAP, while the yield parameters were assessed at harvest. Six plants in the net plot in each replicate were tagged and used for data collection. The data collected were analyzed using analysis of variance (ANOVA) procedures using the GenStat Package Version 8.1. Significant means were compared using the Least Significant Difference at 5% level of probability.

4 RESULTS AND DISCUSSION

The physico-chemical properties of the soil at the experimental site before planting and after harvesting are shown in Table 1. The soil at the site had high sand content with a sandy texture but the silt and clay fractions were low in both samples. The soil initially had low nutrient content which is characteristic of sandy soils.

However, total Nitrogen, organic matter, exchangeable k, Ca, and ECEC contents except available Phosphorus increased in the post-harvest soil sample, indicating favourable influence of legumes on soil fertility due to nitrogen formation and decomposition of litter fall.

Brassinolide significantly (P = 0) improved the vegetative growth parameters of Bambara groundnut at 15 WAP in the screenhouse and in the field presented. The best growth was obtained in plants sprayed at 3 WAP, followed by 6 WAP, and then 9 WAP while unsprayed plants were the least (Table 2). Wide canopy spread, long leaf petioles and early flowering were recorded in the screenhouse, while tall plants with more leaves and high leaf area index were observed in field plots. This shows clearly that early spraying of brassinolide is more advantageous for enhanced growth of Bambara groundnut whether grown in the screenhouse or in the field.

Table 3 shows that spraying Bambara plants at 3 WAP also had more favourable effect on the seed yield parameters than those sprayed at later growth stages. Large seeds were produced only in the screenhouse whereas field plants produced heavyweight seeds, high dry matter and high seed yield similar to the yield obtained by Shiyam *et* al., (2016) in the same environment.

The vegetative growth and seed yield variation at the different stages of application of brassinolode to Bambara groundnut showed that sprayed plants were superior in all parameters evaluated with the best plants being those sprayed early at 3 WAP. However, the effect of the plant growth hormone became progressively less effective as the growth stage increased. This is a strong indication that plant growth hormones are more effective when applied at early crop growth stages than when they become more mature. Applying brassinolide at 3 WAP was more effective and could be adopted to boost the productivity of field grown Bambara groundnut in the humid areas.

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Table 1. Physico-chemical characteristics of initial and post-harvest soil samples at the experimental site
(combined screenhouse and field samples).

Physical properties	**Initial**	**post-harvest**
Sand (%)	73.0	80.0
Silt (%)	16.0	13.0
Clay (%)	11.0	7.0
Texture	Sandy soil	Sandy soil
Chemical Properties		
pH	5.2	5.0
Total Nitrogen (%)	0.10	0.14
Organic matter (%)	2.12	2.60
Base saturation (%)	87	88
Available phosphorus (mg/kg)	33.25	38.25
Exchangeable Potassium (cmol/kg)	0.11	0.13

Exchangeable Calcium (cmol/kg)	4.1	4.2
Exchangeable Magnesium (cmol/kg)	2.0	2.0
Exchangeable Sodium (cmol/Kg)	0.09	0.08
Aluminum ion (cmol/kg)	0.68	0.30
Hydrogen ion (cmol/kg)	0.16	0.56
ECEC (cmol/kg)	7.14	7.27

Table 2. Effect of spraying stage on vegetative growth of Bambara groundnut in Calabar

	Screenhouse Experiment						Field Experiment					
Treatment	PH	CS	L/P	PL	**D50 % (days)**	LAI	PH	CS	L/P	PL	**D50 % (days)**	LAI
Control	33.68	49.00	108.40	2.74	50.60	0.580	66.10	41.06	381.0	2.74	59.80	0.481
Spraying @ 3 WAP	53.60	68.90	150.20	3.44	48.10	0.637	82.20	59.68	455.4	3.22	56.60	0.680
Spraying @ 6 WAP	40.88	64.90	132.60	3.01	49.20	0.621	73.60	49.56	463.0	2.97	58.60	0.651
Spraying @ 9 WAP	35.46	54.20	124.40	2.74	50.80	0.542	67.60	48.99	389.6	2.80	60.20	0.588

Key:

PH: Plant height (cm); CS: Canopy spread (cm); L/P: Leaves/plant; PL: Petiole length (cm); LAI: Leaf area index; D50 %: Days to 50 % flowering of plants in each treatment after planting (days)

Table 3. Effect of spraying stages of Brassinolide (plant hormone) on flowering and yield parameters of Bambara groundnut *(Vigna subterranean* (L) Verdc.) in Calabar

Treatments	NF/P	NOD	NOP	SS (mm)	NSP	PL (mm)	SW/P (g)	DM (g)	SY (t/ha)
Screenhouse Experiment									
Control (no	3.6	5.20	3.00	8.20	1.00	12.54	2.93°	17.70	0.85 /
Spraying @ 3	5.8	6.60	5.80	10.08	1.40	13.25	9.93	19.81	1.80
Spraying @ 6	3.2	4.60	4.50	8.56	1.40	12.80	6.18	18.62	1.58
Spraying @ 9	3.2	5.20	3.40	8.54	1.40	12.68	4.06	18.03	1.12
LSD (0.05)	0.90	NS	1.42	1.47	NS	0.40	2.03	0.80	0.25
Field Experiment									
Control (no	4.40	7.20	4.00	8.22	1.00	12.44	4.82	33.36	0.78
Spraying @ 3	4.00	8.00	9.60	9.60	1.40	13.48	11.36	34.03	1.92
Spraying @ 6	4.40	7.60	6.90	8.34	1.20	13.20	7.24	33.75	1.43
Spraying @ 9	4.60	7.20	5.00	7.68	1.40	13.14	4.95	33.65	1.02
LSD (o.o5)	0.60	NS	1.40	1.66	NS	NS	2.16	0.50	0.20

Key:

NF/P = number of flower per plant; NOD = number of nodules per plant; NOP = number of pods per plant; PL = pod length; NSP = number seed per pod; SS = size of seed; SW/P = seed weight per plant; DW = dry matter yield; SY = seed yield per hectare

Variation in flea beetle infestation, damage and control with cypermethrin on different genotypes of the West African okra [*Abelmoschus caillei* (A. Chev.) Stevels]

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ABSTRACT

Field experiments were conducted in the 2018 and 2019 cropping seasons to assess the infestation and damage caused by adult flea beetles (*Podagrica uniforma* and *P. sjostedti* Jacoby) on four genotypes of *Abelmoschus caillei* (A. Chev.) Stevels, and to evaluate the efficacy of cypermethrin in controlling the pest. The set up was a split-plot design. The main plot factor consisted of sprayed and unsprayed portions, while the subplot factor was the four genotypes of *A. caillei* [NGB 01200, NGB 01204, NGB 01205, and MKD-local (check)], each replicated four times. Results showed that the insecticide reduced ($P < 0.0001$) infestation and damage by both beetles in all genotypes of *A. caillei* tested. Infestation and damage caused by beetles were higher ($P < 0.0001$) in the local variety (local) compared with other genotypes. There were no chemical application × genotype interaction effects for all the parameters evaluated. However, NGB 01205 had the lowest infestation, damage, and the highest yield values when compared with the other genotypes. We conclude that the use of NGB 01205 of *A. caillei* will minimize infestation/ damage by *Podagrica* spp. and maximize crop yield.
Keywords: *Podagrica*, okra, insecticide, field pest, pest management

INTRODUCTION

The West African okra, *Abelmoschus caillei* (A. Chev.) Stevels belongs to the family Malvaceae and is one of the most important and widely utilized crop species. The leaves, fruits, flowers, seeds, stem (fibre), and roots have been subjected to a wide variety of food, therapeutic, aesthetic, and industrial uses (Ekoja *et al*., 2022).

Production of okra in Africa is faced with several biotic and abiotic constraints. Insect pest infestation is one of the important biotic factors limiting okra production. The economic losses depend on pest density, degree of damage inflicted, environmental conditions, stages of growth, and the parts of the plant damaged by pests (Pitan and Ekoja, 2011). Some of the yield-reducing species reported in West Africa include but are not limited to the shoot and fruit borer (*Earia vitella* Fabricius), flea beetles (*Podagrica* spp.), whitefly (*Bemisia tabaci* Gennadius), leaf roller (*Sylepta derogata* Fab.), aphid (*Aphis gossypii* Glover), cotton stainer (*Dysdercus* spp.), green stink bug (*Nezara viridula* Linnaeus) etc (Obeng– Ofori and Sackey 2003, Pitan and Ekoja, 2011). Most damage to okra in Nigeria is inflicted by the flea beetles, *Podagrica uniforma* and *P. sjostedti* Jacoby. Their population could be greater than 90% of the total insects infesting okra at the vegetative growth stage. They are responsible for the characteristic buckshots (round feeding holes) on the leaves of okra (Odebiyi, 1980, Pitan and Ekoja, 2011) which is known to cause significant loss in crop yield (Obeng-Ofori and Sackey, 2003; Ekoja *et al*. 2012).

Quantitative information on infestation and damage caused by *Podagrica* spp. on different varieties of *A. caillei* is still scanty. Most studies conducted in the last decade focused on infestation and damage done to *A. esculentus* genotypes. The increasing demand for *A. caillei* in Africa makes it imperative to direct research on factors that could limit the production of this okra type. Such information will also help our understanding of the damage potentials of flea beetles as well as their economic status on *A. caillei*. Therefore, this study was carried out to assess the infestation and damage induced by adult *Podagrica* spp. on four varieties of *A. caillei*, and to assess the efficacy of cypermethrin in managing the pests in the field.

MATERIALS AND METHOD

Experimental site

The experiment was conducted at the Crop Production Unit of the Teaching and Research Farm of Federal University of Agriculture Makurdi (FUAM) during the rainy season (June – September) of 2018 and 2019 (coordinates: Latitude 7º45’03.4"N Longitude 8º37’43.6"E, elevation: 92 m above sea level, agroecology: Southern Guinea Savannah).

Source of planting materials

NGB 01200, NGB 01204, NGB 01205 genotypes were obtained from the National Centre for Genetic Resources and Biotechnology, Ibadan (NACGRAB), while the MKD-local was obtained from the Department of Crop and Environmental Protection, FUAM.

Experimental procedure

The design was a split-plot arrangement. The main plot factor consisted of sprayed and unsprayed plots while the sub-plot factors are the four genotypes of *A. caillei*. Field infestation by *P. uniforma* and *P. sjostedti* was natural in both seasons. The field was cleared and ridged manually. About 4 cm deep holes were made and three seeds were planted directly in each hole and later thinned to two plants per stand. Seeds were planted on the ridges at 40 cm between each stand and 60 cm between ridges. Cyperkill® (cypermethrin 20EC) at 1.0 ml/ L was applied as from 2 weeks after sowing (WAS). NPK 20:10:10 was applied at the recommended dose at 3 weeks after sowing (WAS). Weeding was done manually at 3, 7 and 10 WAS. Harvesting was also done manually at 4 days intervals. The number of *P. uniforma* and *P. sjostedti* per plant was counted at 9 WAS (n = 10 plants per plot). Other data collected were the number of damaged leaves per plant at 9 WAS, damaged leaf area (cm^2) per plant at 9 WAS, number of fruits per plant, number of damaged fruits per plant, and yield (t/ha).

Statistical analyses

Table 1: Effect of cypermethrin and different varieties of *Abelmoschus caillei* (A. Chev.) Stevels on adult *Podagrica* spp. population

	P. uniforma		*P. sjostedti*		Flea beetle population	
Spray regime (S)	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
Sprayed	2.44	3.31	0.75	1.44	3.19	4.75
No spray	27.88	28.03	3.13	5.19	31.01	33.22
FLSD (0.05)	2.54	2.08	0.73	0.60	2.51	2.33
***P*-value**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Genotype (V)						
NGB 01200	14.90	15.63	2.00	3.75	14.16	19.38
NGB 01204	13.04	14.75	1.13	3.13	16.90	17.87
NGB 01205	10.41	7.86	0.75	1.25	11.16	9.13
MKD-Local	22.29	22.88	3.88	5.13	26.16	28.00
FLSD (0.05)	3.60	2,95	1.04	0.85	3.55	2.19
***P*-value**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
S × G	0.0605	0.0715	0.3921	0.1250	0.1005	0.0905

Means are value from four replicates; FLSD (0.05) = Fisher's least significant difference at 5% level of probability; *P*-value = Probability value

Insect count (x) and data in percentages were transformed to log (x + 1) and arcsine values respectively before analysis of variance was conducted using the 9.2 version of SAS Institute (2009). Where *F*-statistics was significant, means were separated using Fisher's least significant difference at 5% level of probability. Pearson's correlation analysis between the flea beetle infestation, damage, and yield parameters was also carried out on data in both years.

RESULTS AND DISCUSSION

In both years, the use of cypermethrin reduced flea beetle infestation significantly ($P < 0.0001$) in all the varieties of *A. caillei* tested (Table 1). This was consistent with the report of Singh *et al*. (2015). The high infestation and damage observed and the resultant effect on yield further showed that the insects are major biotic constraint of okra production as reported in previous studies (Odebiyi, 1980; Pitan *et al*, 2007; Obeng Ofori and Sackey, 2003; Pitan and Ekoja, 2011; Ekoja *et al*. 2022). All the genotypes of *A. caillei* tested were susceptible to infestation and damage by both *P. uniforma* and *P. sjostedti*. In addition, the population of *P. uniforma* was higher than that of *P. sjostedti* all through the growing period in 2018 and 2019.

Flea beetle-induced damage was significantly higher ($P < 0.0001$) in the local variety than in other *A. caillei* genotypes (Table 2).

Table 2: Effect of cypermethrin and different varieties of *Abelmoschus caillei* (A. Chev.) Stevels on damage induced by adult *Podagrica* spp. and okra yield at Makurdi, Nigeria

Spray regime (S)	Damaged leaves per plant (%)		Damaged leaf area (cm^2)		Damaged fruits per plant (%)		Fresh fruit yield (t/ha)	
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
Sprayed	7.70	9,90	19.21	18.21	1.45	2.43	4.34	3.98.
No spray	86.62	87.31	79.44	89.44	17.45	19.22	0.91	0.85
FLSD (0.05)	1.54	1.55	7.59	7.90	5.27	4.73	0.33	0.32
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Genotype (G)								
NGB 01200	43.56	44.92	59.34	52.34	17.86	18.88	2.13	2.08
NGB 01204	43.83	44.93	46.44	49.44	13.19	14.19	2.89	2.71
NGB 01205	41.16	38.06	38.71	41.50	7.58	8.75	3.96	3.77
MKD-Local	45.41	46.51	62.81	70.81	25.50	26.70	1.52	1.43
FLSD (0.05)	1.30	2.19	10.74	11.17	6.85	6.69	0.47	0.46
P-value	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001
S × G	0.1021	0.1101	0.0897	0.1805	0.0714	0.0774	0.0889	0.0707

Means are obtained from four replicates; FLSD (0.05) = Fisher's least significant difference at 5% level of probability; *P*-value = Probability value

Table 3: Pearson's correlation coefficients showing the association between the flea beetle infestation, damage and yield parameters evaluated

Infestation/ damage parameters	Flea beetles population		Fresh fruit yield (t/ha)	
	2018	**2019**	**2018**	**2019**
Flea beetle population	1.000	1.000	-0.867**	-0.848**
Percentage of damaged leaf	0.906**	0.874**	-0.879**	-0.870**
Damaged leaf area	0.966**	0.963**	-0.867**	-0.845**
Percent damaged fruits	0.952**	0.934**	-0.868**	-0.888**

** = $P < 0.0001$

Most phytophagous insects are known to discriminate among hosts as a result of differences in morphological features or chemical changes brought about by phagostimulants and other secondary metabolites (Pitan and Adewole, 2011).

The treated plots had higher ($P < 0.0001$) fruit yield than the untreated. Apparently, the continuous leaf feeding by the beetles caused significant defoliation and reduction in the photosynthetic capacity of the plants leading to a negative impact on fruit production. This is in consonance with the findings of Pitan and Ekoja (2011) and Ekoja *et al*. (2012) who reported significant impact of leaf feeding by the beetles on chlorophyll concentration and yield of okra. However, infestation and damage were significantly lower ($P < 0.0001$) in NGB 01205 and its yield was significantly higher compared with other varieties.

There were no chemical application × genotype interaction effects ($P > 0.05$) for all the infestation and damage parameters evaluated. Pearson's correlation results showed strong positive associations between flea beetle infestation and damage ($r > 0.870$; $n = 32$; $P < 0.0001$) while the correlations between yield and flea beetle infestation/ damage were negative ($r > -0.840$; $n = 32$; $P < 0.0001$) (Table 3)

CONCLUSION

The study showed that *P*. *uniforma* and *P*. *sjostedti* are important insect pests of *A. caillei* at Makurdi, Nigeria. However, the use of cypermethrin 20EC could reduce infestation and damage significantly in all the genotypes tested. Infestation and damage were lower in NGB 01205 variety and the yield from plots with the genotype was significantly higher compared with other genotypes. Therefore, the use of NGB 01205 genotype of *A. caillei* at Makurdi, Nigeria will minimize infestation/ damage by *Podagrica* spp. and maximize okra yield.

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Morphological characteristic of pigeon pea genotype (*cajans cajan*) using seed image analysis

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ABSTRACT

Computer seed digital imaging was utilized in this study to evaluate the differences in seed metric traits in thirty accessions of pigeon pea and the extent of associations among these traits. Hundred seeds in each of the pigeon pea accessions were subjected to digital imaging analysis using the inSEEDLE™ software to differentiate the seed metric characters. For every replication, hundred seeds were placed on lighting hood in such a way that embryo axis of seed faces image analysis system and longitudinal axis running parallel to the surface of the scanner. Seeds were automatically analyzed by the scanner and the image of the seed recorded by the 'WinSEEDLE™'. The procedure was repeated three times. The parameters observed were total projected area, average projected area, projected area, straight length, curve length, straight width, curve width, volume circle, surface area circle and projected perimeter. Data collected were subjected to ANOVA,principal component analysis and Pearson's correlation analysis. Accessions NSWCC-34 and NSWCC-32 showed superiority in most of the seed metric traits. Most of the trait examined showed positive and significant relationship among one another. The principal components result indicated that seed projected area, seed straight length, curve length, straight width, curve width, volume circle and surface area circle were traits that contributed highly to the variation within the pigeon pea accessions examined. The two identified superior genotypes as well as those traits with high contribution to the major variation could be included in the seed improvement programme for improved seed quality in pigeon pea.

INTRODUCTION

Pigeon pea {*Cajanus cajan*) is a perennial legume from the family Fabaceae. It has been domesticated in South Asia at least about 3,500 years ago and since then its seeds have become a common food grain in Asia, Africa, and Latin America (Singh and Singh., 2016). Pigeon peas are now widely cultivated in all tropical and semi-tropical regions of the world. It can be perennial in nature, in which the crop can last three to five years or an annual variety more suitable for seed production (Gyulai *et al*.,2015).The different seed metric measurements on seed are very essential quantitative variables for determining size and shape of seeds (Arapa and pardon.,2014). Seeds size and shape are major determinants of seed dispersal and probable loss (Gyulai et al.,2015), moisture imbibition and germination of seeds and grain grading quality. In addition, demand for seed grains for human consumption could have relationship with size and shape of seeds. However, the use of morphometric characteristics of seed may provide a useful management strategy for increasing establishment count in pigeon pea, thereby leading to higher yield.

Image analysis has become a very important laboratory tool for cultivar description for a long time. Smith *et* al (Mandel., 2012) has reported micro computerized video image analysis as an effective research tool for the study of genetic expression in *Zinnia elegans.* Apart from the use of image analysis for genetic comparison, it has been used in various ways to determine seedquality. Shende and Rant (2013) used image analysis system to study the process of imbibitions in white cabbage *(Brassica oleracea*L.) seeds. Also, Nune and Escobedo., (2015) described computer image analysis as a very promising technique to determine mechanical damage in seeds because the method is precise and examines seeds individually using enlarged images in which damaged areas as well as their exact location and extension can be found and examined in detail. Since this test is a nondestructive method, analyzed seeds can be submitted to other physiological tests to establish the relationship between the result of the image analysis and other physiological tests. The study was initiated to evaluate differences in computer determined seed physical (metric) characteristics in some pigeon pea accessions and extent of associations among these traits.

MATERIALS AND METHODS

This experiment was conducted at the laboratory of the Department of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta, Nigeria. Seeds of 30 accessions of pigeon pea obtained from International Institute of Tropical Agriculture, (IITA), Ibadan and Institute of Agricultural Research and Training (IAR&T), Ibadan were used for the study.
An EPSON scanner was connected to a computer device to acquire image and the Regent Instrument (Regent Instrument Inc, Canada) was used for the image analysis by running the custom written software WinSEEDLE^{TM} (Pro Version). For every replication, hundred seeds was placed on lighting hood in such a way that embryo axis of seed faces image analysis system and longitudinal axis running parallel to the surface of the scanner. Seeds were automatically analyzed by the scanner and the image of the seed recorded by the 'WinSEEDLE™'. The procedure was repeated three times.

The parameters that were recorded include: total projected area, average projected area, projected area, straight length, curve length, straight width, curve width, volume circle, surface area circle and projected perimeter.

DATA ANALYSIS

The data collected were subjected to Statistical Analysis System (SAS™, 2017) procedures for Analysis of Variance (ANOVA), Principal component analysis (PC A) and Pearson's correlation analysis.

RESULTS

The accessions differed significantly with respect to total project area, project area, straight length, curve length, straight width, volume circle, surface area circle, width length and projected perimeter (Table 1).

Table 1: Mean square values of morphometric traits evaluated in pigeon pea genotypes

Character	Replicates	Genotype effect	Error
Total projected area	3288892-6.81	1158534.87**	358064.16
Average projected area	63827.62ns	6238599.90**	1970084.64
Project area	27.16	42.68**	7.31
Straight length	1.87	3.62**	1.04
Curved length	2.69	3.80**	1.06
Straight width	0.17	0.88**	0.22
Curved width	0.27	0.62**	0.11
Volume circle	202.31	1010.59ns	784.94
Projected perimeter	30.93	50.13**	19.14
Degree of freedom	2	29	55

Significant at 1% probability level * Significant at 5% probability level ns Not significant

Table 2 shows the mean values for the morphometric performance of thirty pigeon pea genotypes. In terms of total project area, Tcc 8127 had the highest mean value of 4243.65mm^2 which differed significantly from all the other genotypes while genotype Tcc811 recorded the least performance. For project trait, all the genotypes had statistically similar values except Tcc 8127 which had the least mean valve of 3677.75mm. In terms of project area, genotype NSWCC-34C and NSWCC32 recorded the highest menmean values of 28.74 and 28.35mm^2 , respectively.

Table 2 :Mean performance of seed morphometric characters evaluated in 30 pigeon pea genotypes

Genoty pe	Total projec ted area(	Seed Proje	Seed Proje cted area(	Seed Strai ght lengt	See d Cur ved	Seed Straig ht width	Seed Curve d width	Seed Projec ted param	Volume circle(mm)
TCc811	1030.	1087	22.40	6.30	7.07	3.95c	4.30c-	25.63	72.23c-i
CITA	875.7	1136	20.43	6.00	6.59	4.06a	4.20a-	25.35	60.8 le-j
ICPL-	1083.	1082	25.70	6.70	7.85	4.49a	4.88	33.77	86.48a-f
Tcc-1	886.2	1103	18.61	5.67	6.46	3.98a	4.22a-	24.10	58.07f-j
Tcc-	891.6	1101	18.16	5.77	6.72	3.80a	4.22a-	27.07	54.04g-i
CITA2	906.7	1100	18.87	5.70	6.13	4.11a	4.24a-	18.85	57.80f-i
Tcc-2	801.7	1110	15.88	5.19	5.61	3.65b	3.78c-	18.12	47.73ij
AOYT	923.3	1098	20.08	5.72	6.63	3.99a	4.29a-	29.71	64.60c-i
A078-	938.5	1097	17.80	5.43	6.10	5.00a	4.18a-	21.19	66.62e-i
Tcc-	672.9	1123	13.74	5.31	6.21	3.19d	3.66d	24.74	3 3.8 2j
TCC-	925.3	1093	25.39	6.31	6.77	4.70a	4.70a-	21.04	75.57c-i
NSWC	1056.	1085	28.35	6.99	7.37	5.23a	5.28a	21.76	106.12a
NSWC	1124.	1078	27.52	6.52	6.84	5.10a	5.12a	20.23	108.06a
NSWC	802.6	1110	18.20	5.32	5.67	4.1	4.20a-	16.68	63.1 ld-j
NSWC	864.4	1104	20.97	5.75	6.02	4.51a	4.55a-	17.72	71.34e-i
NSWC	894.1	1106	21.17	5.78	6.10	4.42a	4.48a-	17.57	73.77c-i
NSWC	838.2	1107	21.74	5.79	6.17	4.48a	4.54a-	18.25	78.94a-i
NSWC	877.3	1103	22.33	6.01	6.36	4.61a	4.67a-	18.81	79.00a-h
NSWC	863.5	1103	21.52	5.74	6.00	4.54a	4.56a-	17.78	76.92c-i
NSWC	1100.	1081	21.25	5.71	5.93	4.42a	4.60a-	18.28	79.81a-h
NSWC	875.3	1103	22.84	5.96	6.23	4.68a	4.69a-	18.55	81.11 a-g
>'	942:5	1096	24:53	6.13	6.42	4.70a	4.72a-	19.03	91.15a-d
NSWC-	805.9	1110	19.57	5.62	5.91	4.17a	4.24a-	17.33	65.84c-i
NSWC	970.3	1092	23.66	6.08	6.52	4.83a	4.85a-	19.26	89.03a-e
NSWC	1116.	1079	28.74	6.75	7.10	5.22a	5.27a	21.49	107.54a
NSWC	948.8	1094	25.3	6.27	6.53	4.95a	5.02a	19.31	93.34a-c
TCC-	4243.	3677.	18.47	11.1	11.6	3.78a	3.91c-	17.79	56.08g-j
CITA3	737.2	1115	17.76	5.41	5.59	3.90a	4.14a-	19.49	47.12ij
Tcc-8	686.9	7879.	20.43	5.22	5.77	4.31a	4.43a-	19.63	78.10a-h
Tcc6	725.4	1118	14.63	4.65	5.19	3.07e	3.26e	15.67	50.84h-j

Means followed by same alphabet along column are not different from another at 5% probability level.

Mean value of straight length was highest in Tcc 8127 but TCc 6 recorded the least value (4.65mm). Also, Tcc8127 recorded the highest value of curve length (11.69mm) while genotype TCc-6 recorded the least value (4.65mm). For straight width trait, NSWCC32, NSWCC-19 AND NSWCC-34 showed values of between 5.10 and 5.23mm while Tcc6 had lowest value of 3.07mm. Projected perimeter of ICPL87 seed recorded the highest value (33.77m) while TCc-6 had the least value.

Table 3: Correlation coefficient among seed morphometric characters in pigeon pea.

	B	C	D	E	F	G	H	I
Total projected	-0.51**	0.03	0.93**	0.91**	-0.05	-0.07	-0.01	-0.05
Seed project(B)		0.02	-0.48**	-	-0.01	-0.003	0.02	0.05
Seed projected			0.33**	0.28**	0.79	0.91**	0.91**	0.27**
_ Seed Straight				0.98**	0.81**	0.22*	0.22*	0.11
Seed Curve					0.11	0.17	0.17	0.27**
Seed Straight						0.87**	0.78**	0.08
Seed Curve							0.85**	0.23*
Volume circle(H)								0.08

Correlation significant at 1% level * correlation significant at 5% level

Total project area recorded a positive and highly significant correlation with straight length (r=0.93) and curve length (r=0.91) (Table 3). However, seed projected area had a highly significant and positive correlation with straight length (r=0.33),curve length (r=0.28),straight width (r=0.91), volume circle (r=0.91), and projected perimeter (r=0.27). Similarly, the straight length of the seed had a highly significant and positive correlation with curve length (r=0.98) but also had significant and positive correlation with the curve width(r=0.22). Curve length on the other hand, had a f highly significant and positive correlation with •i the seed projected perimeter (r=0.27), seed straight width (r=0.87), volume circle (r=0.78). Also, seed curve width had a positive and highly significant correlation with seed volume circle (r=0.85), but had a positive and significant correlation with projected perimeter (r=0.23).

DISCUSSION

The result showed variability among the thirty genotypes for all the metric characters except volume circle, surface area, thereby providing performance opportunity for selecting pigeon pea accessions with superior seed physical traits. Wendel and Grover.,(2015) in cotton, Kehinde (2016),Gotmare*et al.,2018* in cotton, all reported genetic diversity in some seed morphometric traits in using seed digital imaging analysis.The principal components result indicated that seed projected area, seed straight length, curve length, straight width, curve width, volume circle and surface area circle were traits that contributed significantly to the variation within the pigeon pea accessions examined. These traits with high contribution to the major variation could be included in the seed improvement programme for improved seed quality in pigeon pea.

The study showed strong and positive associations among mapping of seed morphometric characters, implying that selection for one morphometric character will lead to improvement in the others. Conversely, there was negative association between seed projected and characters such as seed curve length and seed straight length, suggesting that increase in one character will lead to decrease in other characters and the relationship is therefore worthless in seed improvement if the relationship could bring a desirable improvement. Earlier study by Lee and Frang., (2015), Sangseok, (2018), Zavinon*et al.*,2018 observed positive and strong association among some morphometric characters in kenaf after seed digital images analysis.

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Silvicultural response of oil palm (*Elais guineensis*) seedlings to Effective Micro-organisms (EM) based fermented plant extract and other sources of organic media

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ABSTRACT
A field study was conducted in Ishiagu during the 2021 rainy season to determine the silvicultural response of oil palm to effective micro-organisms (EM) and different sources of organic media. The experimental design was a Complete Randomize Design (CRD) with the treatments replicated four times. The four (4) treatments with their specified rates were: T_1 = Fermented Effective Micro-organism at 10 t/ha, T_2 = Poultry Manure at 10 t/ha, T_3 = Gmelina pruning at 10 t/ha and T_4 = Control (No treatment). The following silvicultural (growth) parameters was taken: plant height (cm) per plant, number of leaves per plant and plant girth. Data collected was subjected to statistical analysis using analysis of variance (ANOVA) and treatment means was separated and compared using Fisher's least significant difference (F-LSD) at 5% probability level. The results indicated that there were significant differences between the treatments in relation to the silvicultural parameters measured. In all, the treatment with effective micro-organism (EM) {T1} performed better than other treatments. This was followed by the treatment with poultry manure (T2). Treatment with {T3} (Gmelina mulch) ranked third while the control was the least (T4) in all the parameters measured. Given the results from this study, the application of effective microorganisms in crop production is highly recommended to farmers, followed by poultry manure and *Gmelina arborea* mulch in that order.

Keywords: *Silvicultural response, effective micro-organisms (EM), fermented plant extract, organic media*

INTRODUCTION
The consumers outcry over the residual effect of the utilization of synthetic agro-chemicals in agriculture and forestry production on the health of human being and the agroecosystems has elicited research into alternative, eco-friendly and sustainable agro-inputs (Balogun, Ogbu, Umeokechukwu and Kalejaiye-Matti, 2016)). In an effort to salvage the situation, several technologies are being researched upon focusing among others on the development of short duration and high yielding varieties of crops that are more resistant to pests and diseases; organic manure trials on soil,

agroforestry approaches *et cetera*. These technologies have been certified to markedly improve soil productivity and suppress pest. Other less unexploited alternative is the use of effective micro-organisms (EM). Such amendments has been reported to significantly increase the numbers of beneficial microorganisms in the soil thereby improving the overall health status of the agroecosystem. This is where the use of effective micro-organisms (EM) on trials in crop production comes handy.

Effective Microorganisms (EM) consist of mixed cultures of beneficial and naturally occurring microorganisms (cultured from matured forest) that can be applied as inoculants to increase the microbial diversity of soil, plant, livestock and the ecosystems for sustainable performance. Though, EM is not a substitute for other management practices; but it basically act as a catalyst in agriculture/forestry and environment equilibrium. It consists of these symbiotically existing micro-organisms either in dried or liquid form as against the use of monocultures (Balogun *et al.*, 2016): The beneficial micro-organisms include: Lactic acid bacteria: *Lactobacillus plantarum; L. casei; Streptococcus Lactis*. Photosynthetic bacteria: *Rhodopseudomonas palustris; Rhodobacter sphaeroides*. Yeast: *Saccharomyces cerevisiae; Candida utilis*. Usually known as *Torula, Pichia Jadinii*). Actinomycetes: *Streptomyces albus; S. griseus*. Fermenting fungi: *Aspergillus oryzae; Mucor hiemalis*.

MATERIALS AND METHODS

Location Description

The experiment was conducted at the research and teaching farm of Federal College of Agriculture, Ishiagu, during the 2018 cropping season. The study area, Ishiagu lies within at longitude 07^0 41^1E and latitude 05^0 56^1N in the derived savanna zone of South Eastern, Nigeria. The area has a mean annual temperature of about 30 ^{0}C and rainfall of 1350 mm (Nwite, Igwe and Wakatsuki, 2008).

Experimental Design and Treatment

The experimental design was Complete Randomized Design (CRD) with the treatments replicated four times. The four (4) treatments with their specified rates includes: T_1 = Fermented Effective Micro-organism at 10 t/ha, T_2 = Poultry Manure at 10 t/ha, T_3 = Gmelina pruning at 10 t/ha and T_4 = Control. The test crop used was sprouted palm seedlings which was obtained from National Oil Palm Research Institute, Benin; Edo State. After pre-nursery germination (about 3 inches in height with 2 leaves). The nursery section of the experiment commenced at FCA, Ishiagu research farm.

Agronomic Practices

The experimental site was cleared, stumped, marked and the potted oil palm seedlings were arranged into plots. Each plot consisted of 6 potted oil palm seedlings with a total of 16 plots. Each plot was represented as the net plot. The different soil amendment materials as treatments was applied to each specified plot with the exception of the control plot. The treatments was incorporated into the potted polybags and left for one week to decompose before planting.

Palm seeds was planted directly into the potted polybags at a depth of about 2cm. Weeding operations was carried out manually and hand pulling after planting. More weeding operations continued at intervals of two weeks for proper maintenance of the crop till the termination of the project work at 16 weeks after planting. Plants were randomly selected and tagged on which the following silvicultural (growth) parameters will be taken: (i) Plant Height (cm) per plant: This was determined by measuring the height of the main plant with ruler from the base to the tip of the plant at 2 weekly interval; (ii) Number of leaves per plant: The total number of leaves per plant was determined by counting at 2 weeks interval; (iii) Plant girth: The plant girth is measured using caliper at 2 weeks interval. The data was subjected to statistical analysis using analysis of variance (ANOVA) according to the procedure for complete randomized design (CRD). The treatment means was separated and compared using Fisher's least significant difference (F-LSD) at 5% probability level.

RESULTS AND DISCUSSION

Plant Height of oil Palm seedlings

Table 1 showed the Mean plant height at 2, 4, 6, 8, 10, 12, 14, 16 and 18 weeks after planting. The result of the table above, revealed that T_1 (EM) recorded the highest mean plant height at weeks 2 till 18 after planting with the following figure: 24.13, 24.82, 25.51, 25.72, 26.06, 26.20, 26.50, 27.42 and 27.62 respectively. This was followed by T_2 (poultry manure) with mean plant height of 23.16, 23.56, 23.70, 24.81, 25.04, 25.15, 25.58, 25.78 and 25.98 respectively. Equally, T_3 (*Gmelina mulch*) followed with these values: 22.84, 22.99, 23.56, 23.86, 23.97, 24.67, 24.91, 24.98 and 25.17. The control recorded the least mean plant height as indicated on the table. The results LSD showed that there were significance differences ($P < 0.05$) among the treatments. The results of this study conforms to similar studies by Balogun *et al.*, (2016), Zhang, Han, Li, Liu, Gao, Hou, and Chang, (2005), Khaliq, Abbasi, and Hussain, (2006), Daiss, Lobo, and Gonzalez, (2008) where they recorded increased plant heights in their studies.

Table 1: Mean Plant Height of oil Palm seedlings

	Weeks After Planting								
Trts	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP	16WAP	18WAP
$T_{1(EM)}$	24.13	24.82	25.51	25.72	26.06	26.20	26.50	27.42	27.62
$T_{2(PM)}$	23.16	23.56	23.70	24.81	25.04	25.15	25.58	25.78	25.98
$T_{3(GM)}$	22.84	22.99	23.56	23.86	23.97	24.67	24.91	24.98	25.17
$T_{4(Cont)}$	22.40	22.45	22.48	22.63	22.82	23.36	23.44	23.68	24.73
LSD	1.91	3.14	4.06	1.69**	2.39**	2.80**	2.29**	3.84	3.88

Number of Leaves of oil Palm seedlings

Table 2 above showed the Mean number of leaves at 2, 4, 6, 8, 10, 12, 14, 16 and 18 weeks after planting. From the results of the table above, it was revealed that T_1 (EM) recorded the highest mean number of leaves at weeks 4, 6, 8, 10, 12, 14, 16 and 18 after planting with mean number of leaves of 5.04, 5.06, 5.50, 6.26, 6.38, 6.75, 7.88, 8.81 and 9.94. Treatment 2 (poultry manure) followed with the following values: 4.38, 4.56, 4.96, 5.13, 5.44, 6.06, 7.06, 8.00 and 9.00. Treatment 3 (gmelina mulch) followed with the following values: 4.06, 4.20, 4.36, 4.49, 5.06, 5.13, 5.43, 6.08 and 6.88. The control (T4) had the least values and performance. The LSD results also showed that there were significance differences ($P < 0.05$) among the treatments. The results of this study conforms to similar studies by

Silvicultural response, effective micro-organisms (EM), fermented plant extract, organic media

Balogun *et al.*, (2016), Zhang *et al.*, (2005), Khaliq *et al.*, (2006), Daiss *et al.*, (2008) where they recorded increased number of leaves in their studies.

Table 2: Mean Number of Leaves of oil Palm seedlings

	Weeks After Planting								
Trts	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP	16WAP	18WAP
T_1(EM)	5.04	5.06	5.50	6.26	6.38	6.75	7.88	8.81	9.94
T_2(PM)	4.38	4.56	4.96	5.13	5.44	6.06	7.06	8.00	9.00
T_3(GM)	4.06	4.20	4.36	4.49	5.06	5.13	5.43	6.08	6.88
T_4(Contr)	4.01	4.11	4.31	4.40	4.56	4.73	4.83	5.03	5.13
LSD	0.61	0.51**	0.58	0.42**	0.47**	0.62	0,58**	0.79	0.77

Girth of oil palm seedlings

Table 3 above showed the Mean plant girth at 8, 10, 12, 14, 16, 18 and 20 weeks after planting. From the results of the analysis, it was revealed that T_1 (EM) recorded the highest mean plant girth across the weeks with the following values: 3.29, 3.86, 4.45, 4.87, 5.20, 5.70 and 6.20. This was followed by T_2 (poultry manure) with mean plant girth of 2.93, 3.46, 4.13, 4.27 and 5.03, 5.44 and 5.96.

Furthermore, T_3 (Gmelina mulch) recorded the mean plant girth with the following values: 2.60, 3.01, 3.70, 4.12, 4.49, 5.03 and 5.55. The control recorded the least values across the weeks of study. The LSD results showed significance differences ($P < 0.05$) among the treatments. The results of this study conform to similar studies by Balogun *et al*., (2016), Zhang *et al*., (2005), Khaliq *et al*., (2006), Daiss *et al*., (2008) where they recorded enhanced girth of plant in their studies.

Table 3: Plant Girth of oil palm seedlings

	Weeks After Planting						
Treatments	8WAP	10WAP	12WAP	14WAP	16WAP	18WAP	20WAP
T_1(EM)	3.29	3.86	4.45	4.87	5.20	5.70	6.20
T_2(PM)	2.93	3.46	4.13	4.27	5.03	5.44	5.96
T_3(GM)	2.60	3.01	3.70	4.12	4.49	5.03	5.55
T_4(Contr)	2.04	2.40	3.14	3.87	4.20	4.50	4.88
LSD	0.33**	0.54	0.28**	0.31**	1.18	0.44**	0.45**

CONCLUSION AND RECOMMENDATIONS

The study entitled "silvicultural response of oil palm (*Elais guineensis*) seedlings to effective micro-organisms (EM) and other organic media was investigated in Ishiagu during the 2021 rainfed cropping season. The results indicated that there were significant differences between the treatments in relation to the silvicultural parameters measured. In all, the treatment with effective micro-organism (EM) {T1} performed better than other treatments. This was followed by the treatment with poultry manure (T2). Treatment with {T3} (Gmelina mulch) ranked third while the control was the least (T4) in all the parameters measured. Given the results from this study, the application of effective microorganisms in crop production is highly recommended to farmers, followed by poultry manure and *Gmelina arborea* mulch in that order.

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Comparative study of the varietal effect on *gari* and residue fibre flour from selected cassava roots varieties in South East Nigeria

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ABSTRACT

Eight cassava roots varieties were processed into *gari* (six white fleshed and two yellow fleshed roots). Wet residue fibre obtained during the sieving operation of dewatered mesh cake, were dried and milled into flour. Percentage yield of each *gari* and residue fibre flour samples were determined. Significant differences ($p<0.05$) were observed in all the cassava roots varieties investigated. Cassava root variety TME 419 recorded the highest percentage yield (28.129%) in *gari* having no significant difference ($p>0.05$) with NR 87184 (27.7345%), while the lowest was obtained in Umucass 45 (14.845%). NR 01/0004 (7.470%) was the highest in residue fibre flour yield and Umucass 44 (2.529%) the least

Keywords: Cassava variety, *gari*, residue fibre, flour.

INTRODUCTION

Cassava has to be processed in various ways to reduce its cyanide content to safe levels for human consumption. One of the traditional forms the root is processed is a granular starchy product called *gari*.. The dewatered cassava mesh cake is sieved to remove large fibres and roasted in large shallow open pots to get *gari*. Cassava roots processed into several traditional methods, varies from region to region. These products include cassava, chips, *gari*, lafun and foo-foo (Kayode, 2015). *Gari* is a fermented cassava product (Sandra, 2010) and is of the major products obtained from cassava in the West Africa sub region (Onabolu, *et. al.*, 2002 ,Oduro, *et. al.*, 2000). *Gari* is a partially gelatinized (Sanni, *et. al.*, 2008), free-flowing granular flour with a slightly fermented flavor and sour taste (Olanrewaju,2017, Oti et al 2010, Nwabueze, and Anoruoh, 2009). In West Africa, it is the most consumed and traded of all food products made from cassava roots. Cassava varieties influences the physical, chemical and sensory qualities of *gari* (James*et. al.*, 2012). Cassava already provides livelihoods of more than 5 million farmers and processors (often poor rural women) in Nigeria (Oti, *et. al.*, 2010), as well as to numerous equipment manufacturers, wholesale, retail traders, and transporters. In addition, small-scale *gari* processing has gradually become the main source of non-farm rural employment in many countries (Onyenwoke and Simonyan,2014). Residue fibre incurred from the processing of cassava roots into *gari* and starch often lead to reduction in *gari* and starch yield, thereby leading to high cost of these products. Therefore it is imperative to investigate the residue fibre flour, comparing it with *gari* produced to ascertain if it is varietal dependent. Hence this study was aimed at comparing the varietal effect on *gari* and residue fibre flour from selected cassava root varieties in South East Nigeria.

MATERIALS AND METHODS

Cassava roots (TME 419, TMS 30572, NR 01/0004, TMS 950505, NR 87184, Nwageri, Umucass 44 and Umucass 45) were peeled, washed and grated, the resulting mash was put in a porous sack and allowed to ferment for 3-5 days under atmospheric temperature. the mash was dewatered with screw press. After fermentation, dewatered mesh cake was pulverized, sifted and roasted in iron pan to obtain *gari* (Agunbiade and Adanlawo, 2007). Each wet solid residues obtained from the cassava *gari* processing was weighed and dried in an electrothermal oven (model; DHG) at temperature 60 degree celsius, then weighed again before milling using Thomas Willey mill and Binatone blender model BLG-401.*Gari a*nd residue fibre flour samples were each weighed respectively. Flow chart of the processing of cassava roots into *gari* and residue fibre flour is shown in figure 1.

Percentage yield of cassava *gari*.

Percentage yield of the *gari* produced from each of the cassava varieties roots were determined as described by Oluwole *et al.,* (2004) and Karim *et al*(2009). *Gari* produced were each weighed on a weighing balance respectively. The weight of *gari* obtained was divided by the weight of the cassava variety root before peeling and multiplied by hundred (100).

$$\% \text{ yield of } gari = \frac{\text{Weight of gari sample}}{\text{Weight of cassava roots sample}} \times 100$$

Percentage yield of residue fibre flour.

This was determined using the same method described above. Residue fibre flour obtained was weighed on a weighing balance. The weight obtained was divided with the weight of the cassava variety root before peeling and multiplied by hundred (100) to get the percentage yield of the residue fibre flour

RESULT AND DISCUSSION

The trend in the processing of the harvested cassava root into *gari* in Table 1 showed significant (p<0.05) differences in the results recorded. Residue fibre can be obtained from all the cassava root varieties investigated and processed into flour. However, from the result recorded, there were variations in the percentage yield of both the *gari* and the residue flour, showing varietal dependent. Percentage *gari* yield were from 14.845 % (Umucass 45) to 28.129% (TME 419). Residue fibre flour was from 2.803% (Umucass 45) to 8.312% (NR01/0004). Umucass 44 that had the lowest residue fibre flour of 2.803% should have been the highest in *gari* yield; however it was not the case. Umucass 44 had 18.332% yields as compare to the highest yielded 28.129% (TME 419). This was also the case in Umucass 45 that had the least g*ari* yield (14.845%), also 4.003% residue fibre flour compare to the highest value 8.312% (NR01/0004). Therefore in selecting cassava root for production of *gari* and to obtain its residue flour from the sieving operation of the dried cassava root mesh cake, the variety of the cassava root need to be considered. Baafi and Safo-Kantanka (2007) in their work on the effect of genotype, age and location on cassava starch yield and quality, observed varietal effect on the yield of the cassava starch studied. This residue fibre flour had been used to produce *fufu* and fibre rich cake in Nigeria (Ohuoba *et. al.*, 2019a& b).

CONCLUSION

Residue fibre flour obtained during the sieving operation of dewatered mesh cake in the processing of cassava root into *gari* varies with variety. Results obtained in this study could be a benchmark for the breeder and processor of cassava. In addition these findings had shown the trend in one of the post harvest waste incurred in the processing of cassava roots and the possibility of processing it into flour. This could aid in cassava waste management that is geared towards reduction in post harvest waste and increase food security in Nigeria.

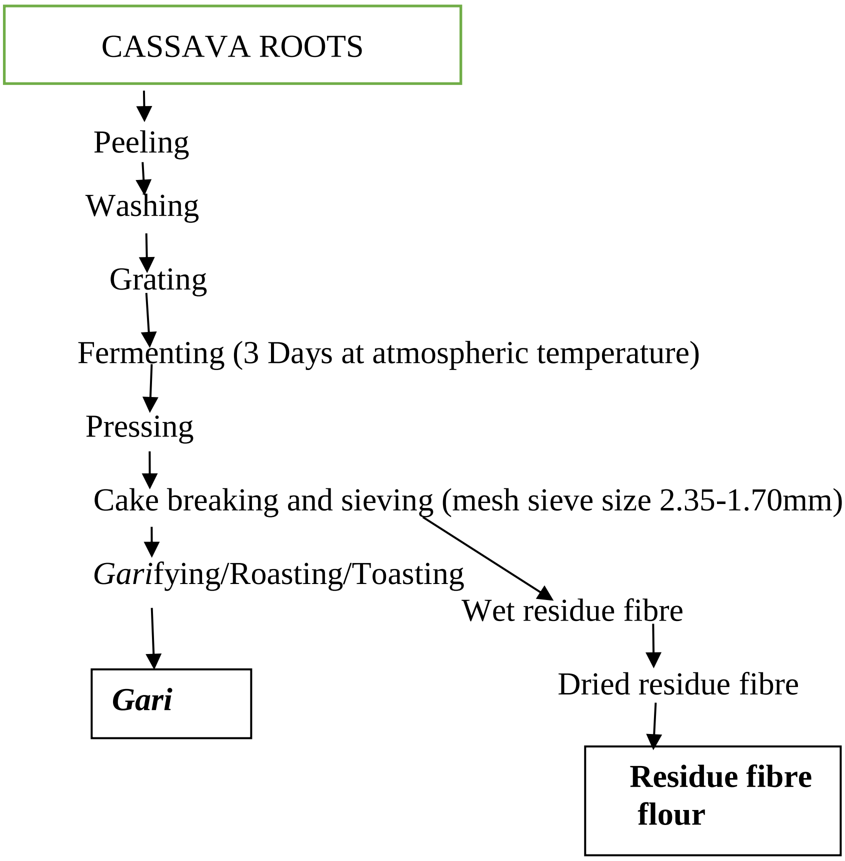

Figure 1: Flow chart of the processing of cassava roots into *gari* and residue fibre flour

Table 1: Percentage of yield of wet cake sieviate, wet residue fibre, dried residue fibre, milled residue flour and *gari*, from eight varieties of cassava roots

Sample	Sieved wet cake	Wet residue fibre	Dried residue fibre	Residue fibre flour	*Gari*

TME 419	42.200^{a} ±0.000	6.333^{d} ±0.001	4.959^{d} ±0.001	4.363^{d} ±0.001	28.129^{a} ±0.001
TMS 30572	40.933^{c} ±0.001	4.333^{g} ±0.000	3.751^{f} ±0.001	3.274^{f}±0.000	19.334^{cd} 0.001
NR 01/0004	40.322^{d} ±0.000	9.160^{a} ±0.000	8.664^{a} ±0.002	8.312^{a} ±0.001	24.194^{b} ±0.001
TMS 950505	31.241^{h} ±0.001	7.774^{b} ±0.001	7.027^{b} ±0.001	6.213^{b} ±0.001	19.569^{c} ±0.000
NR 87184	42.188^{b} ±0.001	6.716^{c} ±0.001	5.980^{c} ±0.001	6.875^{c} ±0.001	27.735^{a} ±0.000
Nwageri	36.976^{f} ±0.000	4.704^{f} ±0.001	3.324^{g} ±0.001	3.245^{g} ±0.001	20.396^{c} ±0.001
Umucass 44	37.333^{e} ±0.000	3.778^{h} ±0.001	2.903^{h} ±0.001	2.803^{h} ±0.001	18.332^{d} ±0.001
Umucass 45	32.500^{g} ±0.000	5.000^{e} ±0.000	4.054^{e} ±0.000	4.003^{e} ±0.001	14.845^{f} ±0.000

Sample means ± standard deviation, Samples means with the same superscript down the columns are not significantly different.($P<0.05$)

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Bio-Pesticide: Akey Measure For Managing Bioytic Stresses Towards Agricultural Sustainability In Developing Worlds

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ABSTRACT

The use of alternative pesticides in crop production reduces environmental pollution and solves pest resistance problems to improve biodiversity. Crop production practices that ensure environmental conservation, economic viability and social acceptability will result in sustainable agriculture. Bio-pesticides have shown to substitute synthetic pesticides with a possible increase in crop productivity. In order to achieve an optimum increase in crops' productivity, bio-pesticides are used in an integrated pest management (IPM) scheme, which goes in line with the aims to achieve minimal use of chemical pesticides at the lowest cost. To improve agricultural sustainability and create environmental pollution free which bring about food security to a nation regarding the application of bio-pesticides, extension of knowledge and skill based on the use of bio-pesticides by the farmers, low cost availability of bio-pesticides and farmers adoption should be the primary task to be dealt with. In view of the above, this paper used analytical approach to reviewthe following: the concept of bio-pesticides,bio-pesticides and their Characteristics,why bio-pesticides are advantageous in agriculture,challenges in the use of conventional pesticides andbio-pesticide and its sustainability in agriculture To maintain agricultural sustainability and environmental pollution free which bring about food security to a nation regarding the application of bio-pesticides, extension of knowledge and skill based on the use of bio-pesticides by the farmers, low cost availability of bio-pesticides and farmers adoption should be the primary task to be dealt with. Governmental organization and private agencies have to make a joint effort cooperate towards manufacturing and sale of bio-pesticides.

.**Keywords: bio-pesticides, key Measures, agriculture,sustainabilities**

INTRODUCTION

Increasing food production is the primary objective of all the countries, as the global population is expected to reach 10 billion by 2050. To feed the ever-growing global population, we need to produce more food from less per capita arable land and available water. Providing enough foods is only the first part of the challenge, and the most important challenge is to produce them in a safe and sustainable manner (kuma,2015). Since most of the cultivated crops have reached their yield potentials, protection of crops to harvest maximum and store them safe are important to meet the increasing food demands as to attain global food security. A large number of pests damage agricultural crops and a significant portion of agricultural inputs is required to protect the crops from them.

Pesticides have been extensively used in the intensive agriculture to reduce yield losses and maintain the product quality. The extensive use of synthetic pesticides has certainly provided protection to the crops; it has also raised concerns about pesticide residues in the food and the environment (Kumar,2013). Chemical pesticides adversely affect beneficial organisms; leave harmful residues in food, feed and fodder, and causes environmental pollutions. More so, human exposure to pesticides occurs primarily through application of pesticide on the crops, contaminated food, feed and drinking water. Their adverse effects depend on toxicity of pesticides, method of application, the dosage applied, their adsorption on soil colloids, the weather conditions prevailing after their application, and how long the pesticides persist in the environment.

The current pest management strategy centres heavily on chemical pesticides which cause adverse effects even on beneficial organisms, leave pesticide residues in food, feed and fodder, and increase environmental pollutions.Intensive agriculture has provided sufficient food grain production so far but it has several environmental consequences. Due to the problems of resistance development in pests and withdrawal of some products for either regulatory or commercial reasons, only a fewer chemical pesticides are available in the market(kumar,2015; Geraldin,Lengai and Muthomi,2018). Out of the 215 pesticides registered for use in India, 39 have been banned for use or withdrawn from the market and this occationed by the adverse effects characterized those chemicals (Geraldin,Lengai and Muthomi,2018).There are rising concerns for the loss of biodiversity and endangered species,and this brings about the requirement to increase agricultural production without excessive reliance on chemical pesticides.

Development of bio-pesticides has largely followed a chemical pesticide model that does not exploit fully the favorable biological properties of the biological agents. While there is commercial pressure from the manufacturing side to develop products, based on a single strain that are broad spectrum in order to control a range of pests on different crops and may not be endemic to the areas of application.Environmentalists prefer narrow spectrum products based on the strains from the area of use. To reconcile these divergent demands, bio-pesticides in the market have been maintained at minimal negative impact, if any, on the environment. This increased public concerns about the potential adverse environmental effects associated with the use of synthetic pesticides which prompted search for the products based on natural resources.

Bio-pesticides are made from naturally occurring substances that controls pests by non-toxic mechanisms and in eco-friendly manner. They are materials with pesticidal properties that originate from natural living organisms, including microorganisms, plants, and animals.

Bio-pesticides may be derived from animals (e.g. nematodes), plants (Chrysanthemum, Azadirachta) and microorganisms (e.g. Bacillus thuringiensis, Trichoderma, Nucleopolyhedrosis virus), and include living organisms (natural enemies), their products (phytochemicals, microbial products) or byproducts (semiochemicals)(kumar,2015;Udemezue *et al*,2021). Bio-pesticides are anything that kills a pest and is biological in origin as opposed to being synthetic chemical. In the potato industry, the best known biopesticide is referred to as Bt, Bacillus thuringiensis. This is an example of a microbial biopesticide. B. thuringiensis is a soil bacterium, toxic to many insect larvae. There are several Bt-products registered on potatoes for foliar applications such as DiPel, Du-Ter and Javelin. Insect-killing genes of B. thuringiensis have also been introduced into the genome of several crops including potato, for example the New Leaf clones of several cultivars. As such, Bt has shown to be most effective. There are also biochemical biopesticides that are structurally related to natural substances and function identically to them. Their actions are non-toxic, so in a literal sense they are not pesticides. Examples are pheromones used to attract (trick) insects into thinking that they are with a mate thereby confusing their mating cycle or to attract them into traps. Bio-pesticides pose less threat to the environment and human health. They are generally less toxic than chemical pesticides, oien targetspecific, have little or no residual effects and have acceptability for use in organic farming. Bio-pesticides generally fall into three major categories: (i) microbial, (ii) biochemical, and (iii) plant-incorporated protectants (PIPs).Their use is best as part of an Integrated Management Program (IPM). They are natural pesticide choice, natural microbial and biochemical pesticides type commonly used by farmers and growers to control an existing pest problem, because they can be applied like synthetic pesticides but without the toxic damage (Soil Technologies Corp, 2021).In view of the above, the broad objective of the study was to review bio-pesticides: a path way for agricultural sustainability in developing worlds. The specific objectives were to review:bio-pesticides and their characteristics, why bio-pesticides are advantageous in agriculture, challenges in the use of conventional pesticides and bio-pesticide and its sustainability in agriculture

Bio-pesticides and their Characteristics

According to SoilTechnologiesCorp(2021),biopesticides are classified into major types:

Microbial pesticides: These biopesticides are produced by microorganisms, including bacteria, viruses, and certain fungi. Each type of micro,bial pesticide targets a specific species or small group of species. It is common that microbial pesticides control a large variety of pests.

Biochemical/herbal pesticides: These are substances naturally occurring in the environment that control pests. This could include plant extracts that lure and trap insects or insect pheromones that interfere with mating. It may include botanical extractions that are active against plant disease pathogens and other pests.

Plant-Incorporated Protectants (PIPs): These pesticides are produced from plants as a result of another genetically incorporated material added to that plant (aka GM crops). While this application of pesticides originates from natural material, it also interferes with the natural biochemistry of the target organism and is thus widely contested.

Generally, all bio-pesticides exhibit the following characteristics (CROPWATCH,2021):

- Highly specific mode of action
- Suppress pests, not eliminate
- Critical timing of application
- Limited field persistence
- Short residual effect
- Safer to environment
- Safer to people

Why bio-pesticides are advantageous in agriculture?

Bio-pesticides have simply been known and understood by many scholars. This implies that plants are well familiar with and responsive to bio-pesticides, without major adverse side effects. Also, natural microbial and biochemical materials are common to our global ecology and are easily processed in our ecology with minimal probability of environmental imbalance. There is the significant difference from synthetic pesticides. Plants and other living organisms are not accustomed or responsive to synthetic molecules, and this unfamiliarity results in rejection or negative reaction and side effects. The plants lack the capacity to store these synthetic chemicals, so its cells can become cancerous, growing abnormally and causing mistakes in normal biological function (CROPWATCH,2021).Bio-pesticides show a number of other advantages over synthetic pesticides, including:

- **Biodegradable and Can be more effective in the long-term**:Effective in small quantities and quickly decompose, avoiding pollution, which is a major problem with synthetic pesticides

- .**Can be less expensive:**Affect only targeted pests, unlike broad spectrum synthetic pesticides that can take effect on other unintended insects, birds, and mammals, including humans

- **Have a host of natural compounds** which may be active against disease and pest, thus minimizing the capacity of pathogenic and invasive organisms to adapt to the molecules, thus rendering them ineffective.

- Bio-pesticides prove to be a predictable and less toxic form of pest control compared to the less predictable and more toxic conventional synthetic pesticides.

Challenges in the Use of Conventional Pesticides

There are harmful effects associated with the use of synthetic pesticides such as toxicity and poisoning(Damalasand Koutroubas,2015).Synthetic pesticides application also lead to environmental pollution due to the un-biodegradable nature of their constituent compounds(Kekuda, Akarsh,Nawaz, Ranjitha,Darshini,and Vidya, 2016) . According to geraldin,lengai and muthomi(2018) , degradation of metham sodium and other fumigant residues were reported to persist up to over six months after application , metham sodium pollutes the air and soil thereby affecting the population of natural enemies in the soil. Methyl bromide has been banned from agricultural use due to its negative impact on the environment. It is associated with depletion of ozone layer which contributes significantly to climate change(Geraldin,Lengai and Muthomi,2018) . The constituent compounds of chemical pesticides contaminate soils rendering them unsuitable for crop production(Kumari, Kumar and Rao, 2014) . They also pollute surface and ground water, killing aqua life after inhalation and consumption(Maksymiv, I2015) . Use of dichloro diphenyl trichloroethane (DDT) for instance led to poisoning of birds, marine species and humans. It has been reported to have carcinogenic properties leading to its ban from agricultural use(Harada, Takeda, Kojima and Tomiyama,2016) .

In a study by Xavier, Chandran, Naseema, Mathew, George,Vijayasree, Pratheeshkumar, and Kumar,2016), application of Fenpyroximate on chilli peppers (Capsicum annum L) resulted in retention of its residues even after sun drying and processing. Similarly, spinosad (spinosyn A and spinosyn D), Indoxacarb and Deltamethrin containing insecticides used to control Rhizoctonia dominica, Sitophilus oryzae and Trogoderma granarium were found to be persistent for up to 120 days after application(Pandey, Gill and Mandal,2016). Continuous use of synthetic pesticides leads to development of resistant plant pathogen strains leading to their resurgence. Farmers apply more chemicals in an effort to eradicate such pests(Halimatunsadiah, Norida,Omar and Kamarulzaman,2016).In the process of managing target pests, synthetic pesticides kill non-target beneficial organisms such as pollinators, predators and antagonists thereby disrupting biodiversity(Ndakidemi,Mtei, and Ndakidemi,2016) .After application, the active compounds of the synthetic pesticides are taken up and retained by crops. Consumption of such crops poses chronic health problems to humans due to the accumulated toxic chemical residues(Jantasorn,Moungsrimuangdee and Dethoup,2016) . Exposing pesticidesto the human population, adversely affects populations and environment. For example, pesticides containing Malathion and Trichlorfon have been reported to cause reproductive complications in humans (Ghorab, and Khalil, 2015) . Exposures to some pesticides have also been reported to retard growth, induce chemical and structural changes in body organs as well as disturb immune responses. They also reduce resistance of animals to disease-causing pathogen infections (Maksymiv,2015). Continuous exposure to pesticides such as chloropyrifos cause gene mutations, genetic damages, reproductive health problems and chronic diseases such as asthma, hypertension and cancer(Dey, Choudhury and Dutta,2015;Geraldin,Lengai and Muthomi,2018).

Horticulture sector in many developing countries has been particularly adversely affected by the use of synthetic pesticides. The European Union (EU) set out strict regulations regarding levels of pesticide residues and safety of agricultural produce exported to their markets. The use of pesticides containing Dimethoate on vegetables was banned by EU. Failure to comply with this regulation led to rejection and destruction of fresh vegetable consignments containing chemical residues above the required limits (Business Daily,2014; Geraldin,Lengai and Muthomi,2018) . Residues of the restricted chemicals should not exceed 0.02 parts per million (ppm) in a sample of vegetables. The percentage of inspection was increased to 10% on fresh produce at ports of entry into the European Union. According to Geraldin,Lengai and Muthomi(2018), Maximum Residue Levels (MRLs) of unknown pesticides should not exceed 0.01mg/Kg and there was imposed a 10% sampling per consignment in fresh beans and pods. Interceptions of fresh produce almost ruined Kenya's export market reputation due to presence of traces of banned pesticides (Business Daily,2014). Following the guidelines made by the EU and the losses incurred due to rejection and destruction of fresh vegetable consignments, there was a reduction in volumes of horticultural exports. This negatively affected the livelihoods of small holder farmers who are the major producers of vegetable crops (Daily Nation,2014) . This led to introduction of a cloud-based traceability system which uses a quick reference (QR) code and GPS coordinates to pinpoint the individual farmer whose consignment fails to comply with regulations(Daily Nation,2016). This has resulted in increase of the cost of production and several farmers opted out of the export business.

Bio-pesticide and its Sustainability in Agriculture

Plant protection is one of the key factors in agricultural production to ensure food security and bio-pesticides appear to be the best alternatives to synthetic chemicals that imposed threat to environment and health. Though there is increasing use of bio-pesticides nowadays but for sustaining the availability of food to feed over growing population, whole system of agriculture across the world should be mechanized and adopt bio-pesticides as control agent of pest. Bio-pesticides have the capacity and potential to replace synthetic chemicals used in pest control. Consequently, it has attracted global attention in recent times for several positive reasons highlighted previously in this paper. Apart from being green molecules, more active substances are discovered through research thereby raising the stance of their potential as innovative pest control agents(Pavela and Benelli, 2016).

Sustainable agriculture systems are those which are economically viable and meet society's need for safe and nutritious food while maintaining or enhancing natural resources and the quality of the environment for future generation. It is in harmony with the environment while maintaining buoyancy and dynamism in agricultural growth for meeting basic human needs and conserving natural resources. It aims at producing food that is both nutritious and safe to human health(Lal,2000; Udemezue,*et al*,2021). Since, all of the materials are of natural or biological origin, it is very safe to use bio-pesticides as potential source of pest control in sustainable agriculture for the benefit of mankind.

Sustainability in agricultural production system is must to meet the growing demand of food with limited availability of resources. Plant protection is one of the key factors in agricultural production and bio-pesticides seems to be the best alternatives to synthetic chemicals(Udemezue,*et al*,2021). Though there is increasing use of bio-pesticides day-by-day but for sustaining the availability of food to increasing population, whole system of agriculture across the world should adopt bio-pesticides as control agent of pest. It is clear that the bio-pesticides are the key for sustainable agriculture and there is urgent need to put more scientific efforts to identify the thrust area of research for the development of eco-friendly production technology with the use of bio-pesticides as a pest control agent.

For this research regarding pest specificity of particular types of bio-pesticides, extension of knowledge and skill regarding use of bio-pesticides to the farmers, low cost availability of biopesticides and farmers acceptance are the primary task to be followed. Both private and governmental organization should make a joint effort in developing, manufacturing and sale of biopesticides(Udemezue,*et al*,2021). Regulation regarding registration of bio-pesticides needs to be made easy so that the commercialization and availability of bio-pesticides in the market is enhanced. Various molecular and biotechnological tools and techniques are being used for producing bio-pesticides in a safe and sustainable manner. DNA recombinant technology is also being used for enhancing efficacy of bio-pesticides. Fusion protein is being designed to develop next-generation bio-pesticides. The technology allows selected toxins (not toxic to higher animals) to be combined with a carrier protein which makes them toxic to insect pests when consumed orally, while they were effective only when injected into a prey organism by a predator(Udemezue,*et al*,2021) . Likewise various innovative tasks are going on to increase the efficacy of bio-pesticides and make it acceptable globally.

Globally, there are 175 registered bio-pesticides active-ingredients and 700 products available in the market. The commonly used bio-pesticides are from neem and Bt derivatives (Moosavi and Zare, 2018; Emmanuel, Grace and Tonderayi,2020). Bt pesticides are the most popular and diversified biopesticides. They are components of most PIPs, biochemical and microbial bio-pesticides. Most recent research indicates that 75% of bio-pesticides used consist of Bt-based products and Neem has proven to be the most widely used botanical bio-pesticide (Pavela, 2014;Pavela and Benelli, 2016; Emmanuel, Grace and Tonderayi,2020).Neem has demonstrated multiple modes of action by acting as an anti-feedant, sterilant, ovicidal and insecticide. However, owing to its instability in environmental conditions, such as sunlight, its effectiveness is short-lived.

To maintain agricultural sustainability and environmental pollution free which bring about food security to a nation regarding the application of bio-pesticides, extension of knowledge and skill based on the use of bio-pesticides by the farmers, low cost availability of bio-pesticides and farmers adoption should be the primary task to be dealt with. Governmental organization and private agencies have to make a joint effort in developing, manufacturing and sale of bio-pesticides. Regulation based on the registration of bio-pesticides has to be easy, so that the commercialization and availability of bio-pesticides in the market is highly sensitized and promoted. Since bio-pesticides are the key for sustainable agriculture, there is urgent need to put more scientific efforts to identify the thrust area of research for the development of eco-friendly production technology with the use of bio-pesticides as a pest control agent. In order to facilitate the market penetration of bio-pesticides, there is a need for cooperation among researchers, venture capitalists, investors, producing companies and farmers with greater considerations placed on long term gains (Rezaei,Safa and Damalas 2019).

Researchers should also consider the alternative ways of using available technologies at the production to scale-up with objectives based on cost reduction, efficiency and reliability of commercial bio-pesticides. This will positively affect the efficacy and reliability of bio-pesticides when integrated into a flexible IPM programme. The programme will ensure the protection of the ecosystem through the use of minimal synthetic pesticides at the most reasonable cost (Emmanuel, Grace and Tonderayi,2020).Training and awareness of bio-pesticides should be organized and implemented among the stakeholders. It should be acknowledged that strict compliance with biological control has more chances to fail and thus should be supported with other variants of pest control options that require awareness and training. The holistic adoption of bio-pesticides and their variant forms including their roles in IPM requires awareness and training among the different stakeholders to sustainably control insect pests and vectors. Researchers should therefore work together with engineers in the government and industry as well as farmers to provide stable and durable formulations of bio-pesticides that will stand the test of time.

CONCLUSION

Pesticides have been extensively used in the intensive agriculture to reduce yield losses and maintain the product quality. The extensive use of synthetic pesticides has certainly provided protection to the crops; it has also raised concerns about pesticide residues in the food and the environment. Chemical pesticides adversely affect beneficial organisms; leave harmful residues in food, feed and fodder, and causes environmental pollutions. More so, human exposure to pesticides occurs primarily through application of pesticide on the crops, contaminated food, feed and drinking water. Their adverse effects depend on toxicity of pesticides, method of application, the dosage applied, their adsorption on soil colloids, the weather conditions prevailing after their application, and how long the pesticides persist in the environment. Sustainable agriculture systems are those which are economically viable and meet society's need for safe and nutritious food while maintaining or enhancing natural resources and the quality of the environment for future generation. It is in harmony with the environment while maintaining buoyancy and dynamism in agricultural growth for meeting basic human needs and conserving natural resources.

Sustainable agriculture can be achieved through the adoption of bio-based pesticides. The use of alternative pesticides in crop production reduces environmental pollution and solves pest resistance problems and improves biodiversity, including natural enemies. Crop production practices that ensure environmental conservation, economic viability and social acceptability will result in sustainable agriculture. As green compounds, bio-pesticides have shown to substitute classical pesticides with a possible increase in crop productivity. In order to achieve an optimum increase in crops' productivity, bio-pesticides are used in an integrated pest management (IPM) scheme, which goes in line to achieve minimal use of chemical pesticides at the lowest cost. With the right education, skill, research on how to improve shelf life and stability problems, and partnerships among stakeholders, bio-pesticide-driven IPM can make chemical pesticide- free agriculture a reality and create a link between socially acceptable economic viability and environmental safety. To maintain agricultural sustainability and environmental pollution free which bring about food security to a nation regarding the application of bio-pesticides, extension of knowledge and skill based on the use of bio-pesticides by the farmers, low cost availability of bio-pesticides and farmers adoption should be the primary task to be dealt with. Governmental organization and private agencies have to make a joint effort in developing, manufacturing and sale of bio-pesticides.

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Antimicrobial activity of selected plant extracts on fungal pathogens of watermelon (*Citrullus lanatus)* fruits and leaves.

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ABSTRACT

Diseases constitute a major challenge to watermelon production in Nigeria through fruit yield and quality reduction. The diseases render the fruits unmarketable and inedible. Hence, this study identified the fungal pathogens associated with the leaves and fruits of watermelon using molecular characterization. The study also evaluated the potential antimicrobial activities of ethanol extracts of three selected plants: (leaves of *Vernonia- amygdalina, Piliostigma- reticulatum and Spondias- mombin*) against the fungal species.

The statistical analysis of the study was done using analysis of variance (ANOVA) and means were compared by using Duncan's Multiple Range test (DMRT).

The results showed that all the plants materials have antifungal potentials on the fungal species with *P. reticulatum* extracts having the highest antifungal activity (100%) at 50mg/ml, 100mg/ml and 200mg/ml. The diameters of inhibition zone varied according to leaf extract and concentration *Vernonia- amygdalina* and *Spondias- mombin* also showed significant zone of inhibition (100%) at 100mg/ml and 200mg/ml.

The study concluded that the plant extracts used have varying anti-fungal reactions on the three fungal pathogens detected and as such can be used as natural antibiotic and antimicrobial agents against plant diseases.

Keywords: plant extracts, fungal, antimicrobial, zone of inhibition.

INTRODUCTION

Watermelon (*Citrullus lanatus)* belongs to the family Cucurbitaceae (Koocheki *et al*., 2007) is a tropical fruit that grows in most parts of Africa and South East Asia. Besides its high nutritional value, it is gaining a high level of economic importance in income generation. Watermelon flesh is an excellent source of vitamins, minerals and anti-oxidants that help in preventing human diseases by acting as oxygen radical scavenger (Reetu *et al.*, 2017). The sweetness of watermelon is due to the

presence of sucrose, glucose and fructose. Sucrose and glucose account for 20-40% and fructose for 30-50% of total sugars in a ripe watermelon (Bianchi *et al.*, 2018).
Diseases such as blossom-end rot, bursting and rind necrosis reduce the yield and quality of watermelon fruit thereby making it unmarketable and inedible which in turn causes loss to the farmers (Donald et al., 2015).

The use of plants extracts is gaining momentum in the last few years in managing plant diseases. Many plants have been used because of their antibiotic and antimicrobial traits, which are due to compounds synthesized during secondary metabolism in the plants. These natural plant products are cheap, readily available, has little or no toxicity to humans (eco-friendly) and are easy to prepare. Therefore, the objectives of this study are to:

- identify some fungal pathogens associated with *C. lanatus* leaves and fruits.
- assess the efficacy of three plant extracts in the management of these fungal pathogens.

MATERIALS AND METHODS

Collection of plants materials

Fresh leaves of *Vernonia- amygdalina, Piliostigma- reticulatum and Spondias- mombin* were collected from Ago Iwoye, Ijebu North Local Government Area, Ogun State in Nigeria. The leaves were collected in polyethylene bags and transported to the Postgraduate Plant Science Laboratory of the Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun State.

Botanical identification

Botanical identifications were carried out at the Elikaf Herbarium, Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

Collection of infected fruits and leaves of *C. lanatus.*

Eighteen infected fruit samples and forty-two infected leaf samples were collected from eleven field in Ijebu North Local Government Area of Ogun State. They were packed into sterilized transparent bags, labeled and transported to Post Graduate Plant Science Laboratory of the Department of Plant Science Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.

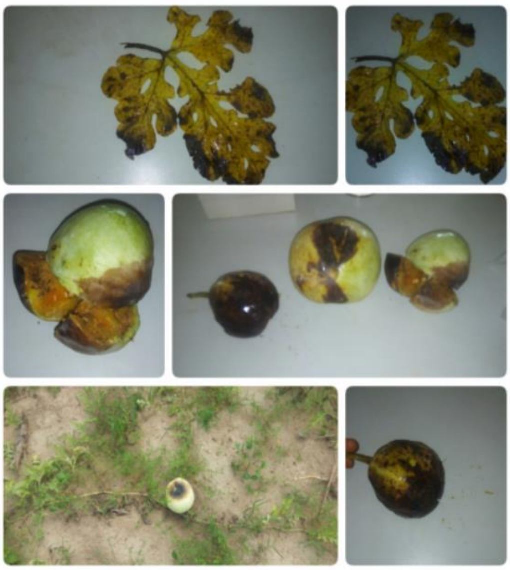

Figure 1: Infected watermelon fruits and leaf samples

Preparation of Culture Media

Potato dextrose agar (PDA) was used as the medium for the growth and maintenance of the fungi isolates.Nineteen and half gram (19.5g) of PDA powder was weighed and dispensed into

500millilitres of distilled water in a conical flask. The mixture was stirred vigorously to dissolve. The conical flask was covered with a foil paper and sealed with a masking tape. The content was sterilized in an autoclave at 121°c for 15 minutes and allowed to cool at room temperature.
The medium was poured into sterile Petri-dishes and allowed to solidify before inoculation was performed.

Isolation of Pathogens from Infected leaves and fruits of *C. lanatus*.

The infected fruits and leaf samples of *C. lanatus* were rinsed in sterile distilled water and small pieces of the rotten parts were picked using a sterile scalpel and placed directly on sterile PDA. The plates were incubated for 3 days at room temperature and sub-culturing was done to obtain pure cultures of the isolate. After incubation, different growths of mycelia colony were sub-cultured with the aid of sterilized inoculating loop into newly prepared PDA plates. The plates were incubated at room temperature for 3-5 days. Several sub-culturing was done, thus purifying the mixed culture plates. The purified fungi were transferred into McCartney bottles of broth agar and stored for characterization.

Identification of Fungi Isolates

The fungal strains were identified using molecular sequencing analysis. The genes (DNA extraction) of the fungal isolates were sequenced with universal primer of (ITS4TCCTCCGCTTATTGACATGS and ITS5GGAACTAAAAGTCGTAACAAGG) and the results are *Fusarium equiseti, Lasiodiplodia theobromae* and*Choanephora cucurbitarum.*

Preparation of Plants Materials

Five hundred grams each of mature fresh leaves of *V. amygdalina, P. reticulatum* and *S. mombin* were thoroughly rinsed in running tap water and air dried at room temperature. The samples were oven dried at a temperature of 55˚C for 30 minutes before grinding into powder with pestle and mortar to facilitate extraction. The samples were ground separately. The leaves were macerated (soaked) in an air-tight plastic container containing 1000ml of 99.9/100% ethanol at room temperature and was stirred using a sterile aluminum rod of 50cm length for 5days to allow for maximum extraction of the plants components and to encourage homogeneity of the plants extract and the solvent used. This was followed by filtration with what-man filter paper and the filtrate was concentrated using water bath. The residue was put into sample bottles as the crude extracts of the test plants and stored.

Concentrations of Crude Extracts

Serial dilutions of the crude extracts were prepared using 0.2g in 1ml of 99.9/100% ethanol and concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml were prepared.

Preparation of Biological Assay

Potato dextrose agar was prepared according to manufacturers' instruction and allowed to cool. The different concentrations of the extracts (25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml) were dispensed into the Petri dishes. The prepared PDA was dispensed into the extracts of the different concentrations, the plates were gently mixed to dissolve the contents using agar dilution method. Four-millimeter diameter of mycelia incubated from old culture of each test fungi was inoculated centrally into the medium using cock borer(4mm) and was incubated for 48 hours to 120hours. The inhibition rate of the plant extracts was observed and measured. The control consists of Petri plates with the organisms but with no plant extract. The inhibition rate was recorded starting from day 2 to day 5. The rate of mycelia growth inhibition (MGI) was calculated using the formula (Jeum *et al.*, 2015):

GI% = dc-dt/dc×100

where dc is mean colony diameter of control sets and dt is mean colony diameter of treatment sets.

Statistical Analysis

Test for significance in the zone of inhibition was done using analysis of variance (ANOVA) and means were compared using Duncan's Multiple Range test (DMRT).

RESULTS

Antifungal effects of the plants extracts on *F. equiseti* at different concentrations

Table 1 shows the percentage inhibition of the plant extracts concentration. On *Fusarium equiseti*, *S. mombin* extracts had percentage mycelia inhibition of 52.80%, 70.30%, 100% and 100% for concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml respectively while the control was 0.00%. For *P. reticulatum*, the percentage mycelia inhibition was 70.53%, 100%, 100% and 100%, while *V. amygdalina* showed the percentage mycelia inhibition of 35.70%, 100%, 100% and 100% respectively.
Ethanol extracts of *P. reticulatum* and *V. amygdalina* at 50mg/ml, 100mg/m and 200mg/ml completely inhibited the growth of *F. equiseti* (100%) while *S. mombin* showed complete inhibition at 100mg/m and 200mg/ml on *F. equiseti*. Thus, the test plants extracts showed no significant difference ($P \geq 0.05$) on *F. equiseti* at 100mg/ml and 200mg/ml while at 25mg/ml and 50mg/ml showed significant difference ($P \leq 0.05$).

Analysis of variance on percentage of *F. equiseti* of the three plants extracts showed significant difference ($P \leq 0.05$) between plant extracts and concentrations of the extracts on *F. equiseti*. The table also shows that the inhibitory effects of the test plants increased with concentrations of the extracts. In comparison, the inhibitory effect of *P. reticulatum* extracts is higher than other extracts at all concentrations.

Table 1: Duncan's Multiple Range Test of Percentage Inhibition (%) at Different concentrations on *Fusarium equiseti*

Table 1.1: Effects of *Spondias mombin* on *Fusarium equiseti*

	Fusarium equiseti	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	Control	3	.0000			
	25 mg/ml	3		58.8000		
	50 mg/ml	3			70.3000	
	100 mg/ml	3				100.0000
	200 mg/ml	3				100.0000
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 1.2: Effects of *Pilostigma reticulatum* on *Fusarium equiseti*

	Fusarium equiseti	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		70.5333	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 1.3: Effects of *Vernonia amgydalina* on *Fusarium equiseti*

	Fusarium equiseti	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		35.7000	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Antifungal effects of plants extracts on *L. theobromae* at different concentrations

Table 2 shows the percentage inhibition of the plant extracts. The percentage inhibition of the plant extracts was concentration dependent on *Lasiodiplodia theobromae*. *S. mombin* extracts had percentage mycelia inhibition of 23.72%, 84.21%, 100% and 100% for concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml respectively while the control was 0.00%. For *P. reticulatum*, the percentage mycelia inhibition was 54.27%, 100%, 100% and 100%, while *V. amygdalina* showed percentage mycelia inhibition of 23.63%, 44.67%, 74.83% and 100%.

Ethanol extracts of *P. reticulatum* and *S. mombin* at 100mg/m and 200mg/ml completely inhibited the growth of *L. theobromae* (100%) while *V. amygdalina* showed complete inhibition at 200mg/ml on *L. theobromae.* Thus, the test plants extracts showed no significant difference ($P \geq 0.05$) on *L. theobromae* at 100mg/ml and 200mg/ml of *P. reticulatum* and *S. mombin* while at 25mg/ml and 50mg/ml showed significant difference ($P \leq 0.05$) on the extracts.

The inhibitory effects of the test plants increased with concentrations of the extracts. In comparison, the inhibitory effect of *P. reticulatum* extracts is higher than other extracts at all concentrations. Analysis of variance showed significant difference ($P \leq 0.05$) between plant extracts and concentrations of the extracts on *L. theobromae.*

Table 2: Duncan's Multiple Range Test of Percentage Inhibition (%) at Different concentrations on *L. theobromae*

Table 2.1: Effects of *Spondias mombin* on *Lasiodiplodia theobromae*

	Lasiodiplodia theobromae	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	Control	3	.0000			
	25 mg/ml	3		23.7667		
	50 mg/ml	3			84.2067	
	100 mg/ml	3				100.0000
	200 mg/ml	3				100.0000
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 2.2: Effects of *Pilostigma reticulatum* on *Lasiodiplodia theobromae*

	Lasiodiplodia theobromae		Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		54.2667	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 2.3: Effects of *Vernonia amgydalina* on *Lasiodiplodia theobromae*

	Lasiodiplodia theobromae	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan[a]	Control	3	.0000				
	25 mg/ml	3		23.6333			
	50 mg/ml	3			44.6667		
	100 mg/ml	3				74.8333	
	200 mg/ml	3					100.0000
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Antifungal effects of plants extracts on *C. cucurbitarum* at different concentrations

The percentage inhibition of the plant extracts was concentration dependent on *Chaonephora cucurbitarum*. *S. mombin* extracts had percentage mycelia inhibition of 22.40%, 32.73%, 42.53% and 100% for concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml respectively while the control was 0.00%. For *P. reticulatum*, the percentage mycelia inhibition was 83.70%, 100%, 100% and 100%, while on *V. amygdalina* showed the percentage mycelia inhibition of 21.33%, 27.10%, 58.83% and 89.46% (Table 3).

Ethanol extracts of *P. reticulatum* and *S. mombin* at 200mg/ml showed a complete inhibition on *C. cucurbitarum* (100%), while *V. amygdalina* showed no complete inhibition at all the concentrations on *C. cucurbitarum*. Thus, the test plants extracts showed no significant difference ($P \geq 0.05$) on *C. cucurbitarum* at 200mg/ml of *P. reticulatum* and *S. mombin* while at 25mg/ml, 50mg/ml and on *V. amygdalina* showed significant difference ($P \leq 0.05$) on the plant extracts.

The inhibitory effects of the test plants increased with concentrations of the extracts. In comparison, the inhibitory effect of *P. reticulatum* extracts is higher than other extracts at all concentrations. Analysis of variance showed significant difference ($P \leq 0.05$) between plant extracts and concentrations of the extracts on *C. cucurbitarum* (Table 3).

Table 3: Duncan's Multiple Range Test of Percentage Inhibition (%) at Different concentrations on *C. cucurbitarum*

Table 3.1: Effects of *Spondias mombin* on *Choanephora cucurbitarum*

		N	Subset for alpha = 0.05

	Choanephora cucurbitarum		1	2	3	4	5
Duncan[a]	Control	3	.0000				
	25 mg/ml	3		22.4000			
	50 mg/ml	3			32.7333		
	100 mg/ml	3				42.5333	
	200 mg/ml	3					100.0000
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 3.2: Effects of *Pilostigma reticulatum* on *Choanephora cucurbitarum*

	Choanephora cucurbitarum	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		83.7000	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 3.3: Effects of *Vernonia amgydalina* on *Choanephora cucurbitarum*

	Choanephora cucurbitarum	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan[a]	Control	3	.0000				
	25 mg/ml	3		21.3333			
	50 mg/ml	3			27.1000		
	100 mg/ml	3				58.8333	
	200 mg/ml	3					89.4667
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Plate A: *F.equiseti* with *V.amygdalina* at 25mg/ml

Plate B:*F.equiseti* with *V.amygdalina* at 100mg/ml and 200mg/ml

Plate C:*C.cucurbitarum* with *P.reticulatum* at 25mg/ml

Plate D:*C.cucurbitarum* with *P.reticulatum* at 100mg/ml

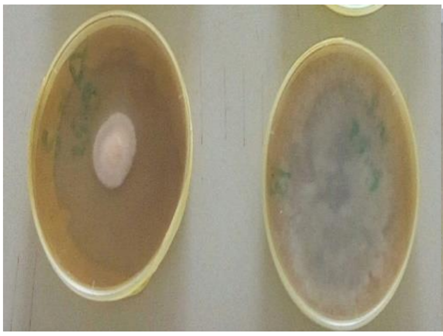

Plate E: *F. equiseti* and *L. theobromae* with *S. mombin* at 25mg/ml

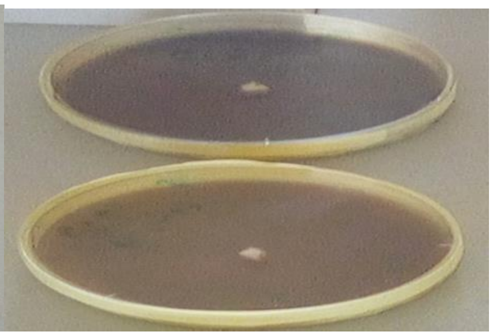

Plate F*: F. equiseti* with *S. mombin* at 100mg/ml and 200mg/ml

Figure 2: Mycelia growth inhibition of fungi with *V. amygdalina, P. reticulatum* and *S. mombin*

DISCUSSION

This study shows three different fungal isolates associated with infected fruits and leaves of watermelon distributed among the seven locations within Ijebu North Local Government Area, Ogun State. *Lasiodiplodia theobromae* appeared in more locations than other fungal isolates on infected fruits and *Fusarium equiseti* appeared in more locations than other fungal isolates on infected leaves of watermelon.

The antifungal effects of *V. amygdalina, P. reticulatum and S. mombin* leaves extracts against; *F. equiseti, L. theobromae and C. cucurbitarum* at different concentrations obtained in this study drastically reduced the mycelia growth of the three fungi strains over a period of 4-5days at (96-120hours) of incubation.

This study revealed the fungal pathogens affecting *C. lanatus* in Ijebu North Local Government Area of Ogun State. In a similar study, Garba *et al*., (2014) reported isolation and identification of bacteria and fungi associated with rots of *Citrullus lanatus* and *Capsicum frutescens* in Sokoto market in Nigeria. List the pathogens detected in Sokoto market. Ratul *et al*. (2010) reported molecular detection and identification of *Fusarium oxysporum* as the fungal species as identified in this study.
Vernonia- amygdalina have been reported to have antifungal activities against some fungal pathogens (Bazie *et al*., 2014; Aondo *et al*., 2016). Stangarlin *et al*. (2011) reported that control of plant diseases using some plant extracts and at different concentrations of *P. reticulatum* on the fungal strains showed a great result of inhibition against the tested pathogen and this could be attributed to the antibiotic properties of the plant. It is therefore a botanical with potential antifungal property (Aderogba *et al.*, 2006). The plant contains very active biological agents that could be used to control fungal diseases of plants.
According to Ngoci *et al*., (2015), *P. reticulatum* extracts show significant antimicrobial activities against some fungi. *Pilostigma reticulatum* had higher antifungal potential compared to other plant extracts used which justified the report of Akomolafe *et al.* (2013), which showed that ethanol and aqueous extracts of *P. reticulatum* have been widely used as herb and also as antibiotic owning to several bioactive constituents it contains. The findings showed that ethanol and aqueous extracts of this plant had strong antioxidant properties.

Garuba *et al.* (2014) reported the ethanolic extracts of *V. amygdalina* showed antifungal potential against *Aspergillus. niger, A. clavatus, A. oryzae, Paecilomyces varioti and Saccharomyces cerevisae*. It was also reported that water extract of *V. amygdalina* leaves have inhibition effect on the growth of *Fusarium moniliforme* and mycelial and conidial growth of *Collectotrichum gloeosporioides* (Owolade *et al.*, 2000; Ogbebor *et al.*, 2007; Suleiman *et al.*, 2008). Nkaa *et al*. (2016) also reported that leaf extract of *S. mombin* reduced the radial mycelial growth of *Proteus-mirabilis* and *Staphylococcus aureus*. Report also showed that ethanol leaf extract of *S. mombin* plant has antifungal activities against some fungal pathogens (Osuntokun *et al.*, 2018) as observed in this study.

CONCLUSION

Findings from this study, showed that the plant extracts used have varying anti-fungal activities on the three fungal pathogens detected.
The observed inhibition zone of *F. equiseti, L. theobromae* and *C. cucurbitarum* suggests that *P. reticulatum* possesses compounds containing antifungal properties that can effectively suppress the growth when extracted with ethanol. Therefore, *P. reticulatum* leaves exhibit the potential of being a good natural antibiotic agent against plant diseases caused by *F. equiseti, L. theobromae and C. cucurbitarum.*

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On-farm evaluation of the performance of potato (*solanum tuberosum L.)* cultivars for stability in mid-altitude environments for adoption

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ABSTRACT

Potato production in Nigeria have suffered due to lack of new high-yielding and resistant varieties among other problems. There is a need to develop or introduce new potato varieties that will increase yield, productivity and well being of farmers in a way that can be sustained. In other to increase yield at farmers level some potato varieties were introduced in 2013. On-station and multi-locational trials were conducted on this varieties a high yielding and early maturing cultivar was identified. On-farm trials were conducted in some villages to evaluate the yield performance of the variety along with other variety with farmers using farmer managed on-farm research approach. The new potato variety was distributed to farmers. Twenty-four farmers were selected from eight villages cutting across four and one Local Government Area each of Plateau and Taraba states. The result indicated that based on tuber yield the variety perform better than the varieties which the farmers are using in all locations. Marit Dutse in Barkin Ladi L.G.A and Vwang in Jos South L.G.A recorded the highest tuber yield of 21.29 t/ha and 20.70 t/ha respectively. Based on this result, marabel and the stability analysis of bertita are recommended for production.

Key words: on-farm, evaluation, cultivar, stability, mid-altitude adoption.

INTRODUCTION

Low yield and unavailability of new improved high yielding potato varieties to farmers constitute a major constraint to potato production in Nigeria. Most of the varieties introduced over the last 3 decades have declined in yield due to virus, fungi, bacteria and many other biotic and abiotic problems. (declining soil fertility) resulting in Nigeria recording the lowest yield of 3.7 t/ha as against the African world average of 7.2 tons/ha and 16.4 tons/ha respectively (F.A.O, 2012). Varieties commonly found in Nigeria includes, Nicola, Diamant, Bertita, among others.

The newly introduced variety marabel has spread to many villages and local government areas of plateau and Taraba states. The adoption rate is low, even though they recognize that it is better than the old varieties in maturity and yield, part of their difficulty is the socio-cultural preference for adapted varieties which they are more familiar with.

Stability performance of crop varieties across contrasting environments is essential to the successful selection of high yielding and consistently performing varieties. A number of techniques have been employed to achieve this goal but regression techniques have been most prominent. Although the usual analysis of variance detects genotype and environment (GXE) interaction when genotypes are evaluated in different environments, only the joint regression analysis is able to furnish the response of varieties. Despite the criticism of this technique (Baker, 1969, Hill, 1975, Powel et al 1986; Ariyo, 1987), it has proved valuable in cultivar development for a number of crops (Breese, 1969) in grass; Ntare and Akeni'ova (1985) in cow peas.

The objectives of the study were:

1. To evaluate the performance of the new variety on-farm against other varieties earlier introduced and are available with farmers and
2. Determine the effect of environment on the varieties

MATERIALS AND METHODS

This study was conducted in 24 farms covering five local government areas of Plateau and Taraba states of Nigeria. The fields where the trials were conducted have not been planted with potato for the past 5 years. Each farmer prepared the plot according to the prevailing local practice which generally, consisted of clearing, burning, packing and making of ridges for both plateau and Taraba states respectively. The treatment consists of four varieties including the new variety supplied by the national root crop research institute potato programme Kuru and Syngenta Nigeria limited, farmer management approach was adopted. Three farmers each from Jos south, Bassa(plateau state) and Sardauna local government (Taraba state). Nine and six farmers each from Barkin Ladi and Mangu respectively. Trial was laid out in a randomized complete block design (RCBD) with four treatments and three replications in each location. Each farmer was used as replication, the plot size was 6m x 5m. Planting was done in the second week of May in all villages. The potato varieties were planted at a spacing of 100cmx30cm on the crest of the ridges. Cultural management such as weeding and earthing-up were carried out according to farmers' practice. Compound fertilizer NPK 15:15:15 were applied at the rate of 500kg\ha (10 bags) at planting.

Data were collected on tuber yield. Data collected in each trial were subjected to individual and combined analysis of variance to examine genotype x environment interaction effect. Joint regression analysis was also performed according to the procedure of Eberhart and Russel (1966) by regressing individual means on the environmental indices to determine the pattern of response. According to this method a genotype with average sensitivity will have a unit regression coefficient (b=1.0) or greater than unity. While a stable genotype will have a low slope (b<1).

RESULTS

The analysis of variance for each location is shown in Table 1. Mean squares for all the locations shows that significant differences exist on all the varieties in each location on tuber yield.

Table 1. Analysis of variance for each location

Locations		Kwi		Foron		Vwang		Merit dutse		kwall		kerang		Ampang west		Gembu	
source	Df	ss	ms	ss	ms	ss	ms	ss	ms	ss	ms	ss	ms	ss	ms	ss	Ms

Reps	2	3.91	1.96	0.50	0.25	2.87	1.43	1.50	0.70	0.55	0.28	0.09	0.004	0.45	0.23	1.50	0.75
Varieties	3	161.82	53.94	145.17	48.39	254.75	84.92	265.74	88.58	323.70	107.90	299.93	99.98	314.47	104.82	304.80	101.60
error	6	0.85	0.14	2.77	0.46	1.50	0.25	1.46	0.24	2.99	0.50	4.02	0.67	3.99	0.67	3.99	0.67
Total	11	166.5		148.44		259.12		288.69		325.70		303.1		318.94		310.29	

Eight locations are presented in Table 2. Locations Marit Dutse, Vwang and Foron were equally favorable for the varieties as they produced 21.29 t/ha, 20.7 t/ha and 18.54t.ha respectively. The lowest yields were produced in Kerang and Kwi 13.60t/ha and 13.18t/ha.

However, KWI had a CV of 2.85% while Ampang west recorded a CV of 5.57%

Table 2: Mean tuber yield and co-efficient of variation for varieties evaluated in 8 locations.

Location	Yield	CV
Kwi	13-18	2.85
Foron	18.54	3.67
Vwang	20.70	3.84
Merit Dutse	21.29	3.63
Kwall	14.19	3.30
Kerang	13.60	5.17
Ampang west	14.69	5.57
Gembu	14.83	5.51
Mean	16.38	4.19
L.S.D	0.70	--

The mean yields of the genotypes are presented in Table 3. The average tuber weight of 13.28t/ha was recorded. Among the entries only Marabel and Diamant produce above average yield. Also varieties Nicola and Bertita had above average co-efficient of variation (cv) and all varieties which produced above average yields had below average cv. In all, marabel with a yield of 21.24t/ha was the most desirable.

Table 3: Mean tuber yield and co-efficient of variation (cv) for Potatoe varieties evaluated

Variety	Mean tuber Yield(t/ha)	cv (%)
Nicola	11.20	7.60
Diamant	13.57	4.95
Bertita	9.30	10.04
Marabel	21.24	2.88
Mean	13.28	6.37
L.S.D	0.78	-

The combined analysis of variance for the varieties are presented in Table 4. Mean squares for all planted varieties were significant. Variety mean square was the largest while varieties x environment was the lowest.

Table 4: Combined analysis of variance for tuber yield of Potato varieties evaluated.

Source	DF	MS
Variety	3	666.400l
Environment	7	5.5936
Reps. Within environment	16	3.1527
Varieties x environment	21	2.6316
Error	48	0.9569

The Joint regression co-efficient (b) and the deviation from regression (s^2d) of the varieties are presented in Table 5. Marabel had the largest regression co-efficient of 1.99, while Bertita had the lowest regression co-efficient of 0.1136. Since the mean square due to variety x Environment (linear) was significant, the regression co-efficient were different from each other. Marabel was sensitive or responsive to the environment and perform better in good environments. While Bertita was stable across all the environments. The deviation mean squares were not significant except for marabel.

Table 5: Regression co-efficient (b) and deviation mean square of the potato varieties.

Variety	Regression	Deviations
Nicola	0.8683	5.8971
Diamant	1.1408	8.4809
Bertita	0.1136	3.0625
Marabel	1.9860	19.4912

DISCUSSION

An essential step in variety development is the evaluation of lines in contrasting environments to determine their desirability or otherwise. It is expected that varieties will respond to increment in environmental conditions. Such responsive varieties are productive especially in good environments. Varieties with average responses over environments had a wide scope of cultivation. With respect to the present study, Marabel and Diamant shows that these varieties are responsive while Bertita and Nicola are productive in varied environments. Successful evaluation of varieties is possible through genotype x environment interaction analysis. Eberhart and Russel (1966) emphasized the need to consider both linear regression co-efficient and non-linear components of genotype x environment interaction analysis.

Samuel et al (1970) and Paroda and Hayes (1971) reported that linear regression co-efficient which could simply be regarded as a measure of the response by a particular genotype is a linear function of the environmental changes. When the sensitivity of a genotype is a linear function of the environment, the yield of that such genotype can be predicted (Ariyo, 1995).

The fact that variety x environment was significant in this study indicated that the varieties responded differently relative to each other in the eight locations. The findings are similar to that of Rajendran et al (1987) who made similar observation in cassava. Also, the significant variety x environment interaction for tuber yield shown by two varieties in this study indicates that breeding potato for improved stability across locations is possible. The results clearly showed that environment and genetic variations mostly accounted for the variation in tuber yield.

CONCLUSION

Breeding potato for high productivity and stability across environments is possible as one variety in this study showed good level of yield and yield stability across diverse locations. Some locations gave better yield than others indicating the possibility of breeding varieties for specific locations.

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Assessing Sweetpotato Current Breeding Lines For High Storage Root Yield And Compatibility As Parents For Genetic Recombination

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ABSTRACT

The experiments were conducted at the Western experimental field of National Root Crops Research Institute, Umudike, Abia State during the 2021 cropping season in the rainforest agro-ecology of Southeastern Nigeria with the following objectives: to produce 10,000 botanical seeds for progeny development and increase genetic diversity, to assess current breeding lines for high storage root yield and compatibility as parents for crosses and to evaluate the sweet potato parents for reaction to biotic stresses. Data collected include: total number of capsules harvested per parent, total number of seeds harvested per parent, total number of good seeds, total number of storage roots, number of commercial roots and number of small roots. Weight of total storage roots, the weight of commercial roots and weight of small roots. Data collected were subjected to Analysis of Variance and means were separated using Standard error of difference (S.E.D). Data were also collected on biotic stresses. Results obtained indicated that the objective of realizing 10,000 botanical seeds were not realized due to the fact that most genotypes in the crossing block were not as prolific as was expected. Genotypes with high number of storage roots, heavy weight of fresh matter accumulation and high number of botanical seeds were selected as parents for use in crossing blocks. The high number of seeds produced was an indication of high compatibility with other genotypes. Higher number of botanical seeds produced indicated high genotype diversity since each seed is a new variety. The genotypes selected for use as parents were immune to most of the field biological stresses and therefore were recommended for use as parents in the hybridization plots. The genotypes are: NWA/OP/241 (9.4t/ha) NWA/OP /226 (9.7 t/ha), NWA/OP/231 (13.1 t/ha) and Smiles (16.1 t/ha).

Keywords: Parents, botanical seeds, weight of roots, crossing block and diversity.

INTRODUCTION

The development of new genotypes involve setting breeding objectives, generating the required genetic diversity through hybridization, recombining the first generations, followed by various forms of selection in subsequent generations to increase the frequency desired characteristics and to fix these, leading to a new variety that is reasonably uniform and stable (Gruneberg et al., 2007; Gibson, 2007). Sweetpotato improvement programmes have been even less successful for the extreme arid and high altitude areas of the country partly because of the allocation of limited research resources by national and international programmes and partly due to Gasura et al, 2008; Lebot, 2009). Nigeria has many genetically diverse, sweetpotato landraces but little use has been made of them in the national breeding programmes. Concerted efforts should be considered for the use of alternative approaches to address the problems of the limited sweet potato varietal choice available to farmers. Traditionally, the development of sweet potato varieties has been the task of breeders, and farmers are merely the recipients of finished products.

Technology arguments. To develop better adapted varieties for the marginal complex environments and, in some cases, for highly productive environments, plant breeders have become increasingly aware that their initial primary concern with yields was not always sufficient to guarantee broad adoption by farmers. Gurmu (2015) indicated that it has become apparent that breeding objectives need to incorporate other criteria, such as local consumption preferences. This has led to farmer-participatory evaluation aimed at establishing what additional characteristics were required, such as taste, colour/appearance and other household requirements, e.g. ease of cooking and of storage. The principal objective of the sweetpotato breeding programme was to generate botanical seeds through which variation in sweetpotato plants could be developed, and this will act as raw material for selection (Akoroda, 2021). Seedlings could then be evaluated to select genotypes that merited utility traits for various end-users. Therefore the breeding objectives were to:

1. To produce 10,000 botanical seeds for progeny development and increase genetic diversity
2. Assess current breeding lines for high storage root yield and compatibility as parents for crosses and
3. To evaluate the sweetpotato parents for reaction to biotic stresses.

MATERIALS AND METHODS

The experiments was conducted at the Western experimental field of National Root Crops Research Institute, Umudike, Abia State during the 2021 cropping season in the rainforest agro-ecology of Southeastern Nigeria. The site for the experiment was slashed, ploughed, harrowed and ridged. The area was then divided into plots and the plots were grouped into blocks. Each of the 20 varieties comprised of 17 current breeding lines at AYT (Advance Yield Trial stage) and 3 Varieties (UMUSPO/3, Erica and Tio–Joe) were used as parents and were planted on the crest of the ridge 0.3m within row and 1.0m between rows in a plot size measuring 3m x 3m and replicated three times which gave a total of 60 plots.

Two months after planting, the plots were staked to enhance the flowering, ease of pollination, reduce soil borne diseases and ease in dry capsule collection from the parent plants. The plots were kept weed free throughout the trial. The parents were subjected to diaelle crossing and all seeds collected from each of the parents were packed in a well labeled envelope. No fertilizer was applied to prevent the crop from growing too luxuriantly and delay flowering. The following data were collected: total number of capsules harvested per parent, total number of seeds harvested per parent, total number of good seeds, Total number of storage roots, number of commercial roots and number of small roots. Weight of total storage roots, weight of commercial roots and weight of small roots. Data collected were subjected to Analysis of Variance and means were separated using Standard error of difference (S.E.D). Data were also collected on biotic stresses and scored on severity scale of 1 to 9 and the data collected were scored using the scale of 1 to 9 (Toker *et a*l., 1999).
Where: 1 = Immune , 2 = Highly Resistant, 3 = Resistant, 4 = Moderately Resistant, 5 = Tolerant, 6 = Moderately susceptible, 7 = Susceptible, 8 = Highly susceptible and 9 = Highly susceptible.

RESULTS AND DISCUSSION

The result on the total number of capsules collected, total number of seeds and total number of good seeds is presented in Table 1.

Table 1: Number of capsules and seeds generated through genetic recombination for the development of new sweetpotato genotypes for varied end-users

Name of Variety	Total Number of capsules harvested	Number of seeds collected	Total number of storage root	Total weight of storage root	SPVD	Leaf Spot	Nematode
UTY/20/017	149.0	147	28.0	10.2	1.0	1.3	1.3
PO3/36	242.0	184	36.0	13.3	1.0	1.2	1.2
NSPO/2014/066	244.0	432	38.0	12.5	1.0	1.0	1.0
87/OP/132	339.0	378	29.0	14.1	1.4	1.0	1.0
NWA/OP/227	138.0	76	15.0	9.4	1.1	1.0	1.0
OSP3/017	366.0	432	19.0	11.2	1.3	1.0	1.0
ERICA (chk)	233.0	166	7.0	2.5	1.2	1.0	1.0
NWA/OP/226	634.0	968	17.0	9.7	1.0	1.2	1.2
OSP3/187	444.0	102	13.0	6.3	1.0	1.1	1.1
TIO-JOE (chk)	733.0	1107	15.0	4.0	1.0	1.0	1.0
OSP3/11	454.0	1032	14.0	5.0	1.0	1.0	1.0
OSP3/31	174.0	219	9.0	3.0	1.0	1.0	1.0
OSP3/119	345.0	290	11.0	2.6	1.4	1.1	1.1
NWA/OP/231	426.0	852	34.0	13.1	1.1	1.1	1.1
SMILES	535.0	972	41.0	16.1	1.0	1.0	1.0
SPO3/47	244.0	332	12.0	4.2	1.2	1.2	1.2
SPO/50	109.0	118	14.0	6.7	1.0	1.0	1.0
NWA/OP/241	229.0	598	23.0	9.4	1.0	1.0	1.0
92SPO3/82	219.0	138	13.0	5.3	1.0	1.0	1.0
UMUSPO/3 (chk)	319.0	653	14.0	4.8	3.0	1.0	1.0
Total	**6576**	**9196**	**426.0**	**163.4**	=	=	=
Mean	328.8	459.8	21.3	8.2	=	=	=
Range	109-733	76-1107	7-41	2.5-16.1	=	=	=
CV%	34.2	38.2	31.3	41.2	=	=	=

The result in Table 1 showed that the total number of capsules with seeds harvested from the sweetpotato genotypes varied greatly from 109 to 733 capsules with mean of 328.8 capsules and coefficient of variation of 34.2%. The genotype that gave the highest number of capsules was Tio-Joe with total number of harvested capsules numbering 733 followed by NWA/OP/266 with total of 634 harvested capsules while the least number of harvested capsule was obtained from the genotype SPO/50 which gave a total of 109 harvested capsules. Capsules contain botanical seed for the development of sweetpotato progenies which will give rise to new sweetpotato genotypes which individually possess different characteristics desired by various end-users. For the fact that most of the new genotypes flowered is an indication that they are out crossing and could be used as parents for sweetpotato hybridization block.

However, total number of botanical seeds collected was 9196 with mean of 459.8 seeds. This varied greatly from 76 seeds as produced by NWA/OP/227 to as high as 1107 as was produced by Tio-Joe with coefficient of variation of 38.2% which indicated a high degree of variation. High number of capsules results into high number of seed yield. Not all pollinated capsules produce the same quantity of seeds. From the results obtained, genotypes that produce high number of capsules produced high number of seeds. High number of seeds and capsules is an indication of high compatibility of the parents with other genotypes in the same crossing block. Therefore genotypes with number of seeds above the grand mean were selected for use as parents in the hybridization block. These genotypes included the following: NWA/OP/226 (968 seeds), Tio-Joe (1107 seeds), SPO/3/11 (1032 seeds), NWA/OP/231 (852 seeds), Smiles (972 seeds), UMUSPO/3 (653 seeds) and NWA/OP/598 (598 seeds).

Number and weight of storage roots: Total number of storage roots varied greatly from 7.0 (NWAOP/227) to 41.0 roots (Smiles) per plot with mean of 7.4 number of roots per plot with 31.3% coefficient of variation. High number of storage roots per plot is a function of yield. Parent genotypes with high number of storage roots could transfer such desirable trait to their progenies. Also high number of storage roots leads to heavy weight of fresh matter accumulation.

The result in Table 1 showed that total weight of storage roots ranged from 2.5t/ha (Erica) to as heavy as 16.1t/ha (Smiles) with mean of 8.2t/ha and coefficient of variation of 41.2% which was an indication of high variation in total storage root weight. Heavy storage root weight is an indication of high dry matter accumulation. Genotypes with high storage root weight plus high number of seeds were selected for as parents for inclusion into hybridization block. The genotypes selected were: NWA/OP/241 (9.4t/ha) NWA/OP/226 (9.7t/ha), NWA/OP/231 (13.1t/ha) and Smiles (16.1t/ha).

Pathological Reactions: The pathological reactions of the genotypes indicated that the genotypes had a mean severity score of 1.0 for *SPVD*, *alternaria* and nematode infestation. Based on the pathological score the genotypes selected were assumed immune to field pathological infectious diseases. However, the SPVD did occur in the field. One of the check varieties UMUSPO/3 had SPVD severity score of 3.3 although (the check variety) was resistant to the SPVD attack.

CONCLUSION:

The objectives of producing 10,000 botanical seeds were not realized due to the fact that most genotypes included in the crossing block were not as prolific as was expected. However, those genotypes with high number of storage roots, heavy weight of fresh matter accumulation and high number of botanical seeds were selected as parents for use in crossing blocks. The high number of seeds produced was an indication of high compatibility with other genotypes. The high number of botanical seeds produced indicated high genotype diversity since each seed is a new variety. The genotypes selected for use as parents were immune to most of the field biological stresses and therefore were recommended for use as parents in the hybridization plots. The genotypes are: NWA/OP/241 (9.4t/ha) NWA/OP /226 (9.7t/ha), NWA/OP/231 (13.1t/ha) and Smiles (16.1t/ha).

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Effect Of Selected Fungicides On Mineral And Phytochemical Compositions Of Cocoyam (*Colocasia Esculentum* L.)

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ABSTRACT

Cocoyam is known to be cultivated by the minority groups in nearly all States of Nigeria, thus gradually leading the tuber crop into extinction. The few cocoyam farmers often suffer loses both on-farm and in storage due to fungi disease which causes low yield. However, the need for increased yield to meet the demands for consumptions and make sales has made cocoyam farmers to resort to the use of fungicides for combating pest and diseases on-farm and in storage. The objective of this study is to evaluate the effect of fungicides (Benomyl and Tecto-40 EC) on mineral and phytochemical compositions. Cocoyam tubers were harvested from the Western experimental field of the National Root Crops Research Institute Umudike, Abia State. Various samples of the harvested cocoyam tubers, both fungicide treated and non-treated were peeled, washed, ground into powder, stored in 2kg packs and analyzed for mineral and phytochemical contents using the appropriate laboratory measures. Data collected were analyzed using SPSS Version 23 and the difference in means at $p<0.05$ was considered significant. Results obtained showed that the crude protein of samples treated with both Benomyl and Tecto-40 EC at 16_WAP were significantly higher than the non-treated samples. The moisture content of the fungicides treated samples at 16_WAP were significantly lower than those of the non-treated samples, an indication of the resistance to microbial attack. Results indicated that the mineral content of the fungicides treated samples were significantly higher than the non-treated samples at 16_WAP, with Tecto-40 EC showing higher values than Benomyl. The results of the investigation showed that the use of Benomyl and Tecto-40 EC increased the mineral and phytochemical compositions of the tuber crops compared to the non-treated samples. It is also recommended that more work is required to determine the bioaccumulative effect of the fungicides on experimental animals.

Key words: Benomyl, Tecto-40 EC, Mineral and Phytochemical compositions.

INTRODUCTION

Colocasia esculentum (L). Schott (cocoyam) is one of the two food crops in the *Araceae* family. It is a perennial tropical plant primarily grown as a root vegetable for its edible, starchy corms. The plant has rhizomes of different shapes and/sizes. The tubers could be roasted, baked or boiled to minimize the toxin (calcium oxalate) it contains in its raw form. The tubers could also be peeled, dried and ground into flour for pastry that can be stuffed with meat or other fillings. The young leaves can be boiled and consumed as vegetable. Thus, provides a substantial contribution to nutritional requirements, for energy, protein and other macro- & micro- nutrients (Adelekan, 2012 and Ikwele et al; 2008). Diseases are the most limiting factors in cocoyam production resulting in significant yield loses. Fungal diseases of cocoyam are usually managed with synthetic fungicides (DoctorFungus, 2012 and Ajima et al; 2011). However, the use of fungicides in the control of diseases (Daisy, 2000 and FAO, 2012) and their effect on the nutrient compositions of the food crop need to be evaluated. Therefore, the present study was carried out to determine the effect of two fungicides (Benomyl and Tecto – 40 EC) on the mineral and phytochemical composition of both the treated and non – treated cocoyam.

MATERIALS AND METHODS

Sample collection and Preparation: Cocoyam tubers were selected from those harvested from the experimental fields of NRCRI, Umudike after 9 months of planting. The tubers were hand peeled using stainless steel knife, washed thoroughly and sliced into tiny pieces. The sliced samples were placed on a stainless steel tray and sun – dried for 5 days. The dried chips were ground using a Warren blender to convert into flour. Then the flour (2kg) was filled in polythene bags, packed and kept in desiccators until analyzed for contents of proximate, minerals and anti-nutritional factors.

DETERMINATION OF PROXIMATE AND MINERAL COMPOSITIONS

The proximate compositions (total moisture content, crude fat, crude protein, crude fibre, ash, total carbohydrate and gross energy values) mineral compositions were determined using the procedures described by the Association of Official Analytical Chemists (AOAC, 2005).

Analyses of the anti-nutritional factors were carried out by the method described by Fana et al; (2015).

STATISTICAL ANALYSIS

Analyses were carried out to determine the difference in proximate compositions, mineral contents and anti-nutritional factors of the Benomyl and Tecto-40 EC treated and non-treated samples. The analyses were performed using SPSS Version 23. Difference in means at $p < 0.05$ was considered significant.

RESULTS AND DISCUSSIONS

The results of the proximate analyses (%) showed that the crude protein in samples treated with Tecto-40 EC at 8WAP and 16WAP (11.34 ± 0.5 and 13.54 ± 0.02, respectively) were significantly higher than the crude protein of samples treated with Benomyl at 8WAP_ (10. 50 ± 0.02 and 11.35 ± 0.04). The crude protein of the non – treated sample at 8WAP (12.23 ± 0.02) was significantly higher than that of 16WAP_ (7.45 ± 0.02). The moisture content of samples treated with Benomyl at 8WAP_ (6.34 ± 0.31) differed significantly from Tecto-40 EC at 8WAP_ (5.61 ± 0.47), while there was no significant difference at 16WAP. Crude fat of both Benomyl and Tecto-40 EC treated showed no significant difference at 8_WAP and 16_WAP. The carbohydrate content of both Benomyl at 8_WAP (78.21 ± 0.26) and Benomyl at 16_WAP (79.86 ± 0.06) were significantly different from that of Tecto-40 EC treated samples (Tecto-40 EC 8_WAP 77.58 ± 0.42 and 77.95 ± 0.16). The dry matter of all the samples were relatively high, an indication of a high nutritional value.

Table 1: Proximate compositions (%) and dry matter content of the Benomyl and Tecto-40 EC treated and non-treated cocoyam.

Samples	*DRY MATTER*	*MOISTURE*	*CRUDE FAT*	*CRUDE FIBRE*	*CRUDE PROTEIN*	*ASH*	*CARBOHYDRATE*	*ENERGY VALUE (KCAL/100g)*
Control - O 8 WAP	94.40 ± 0.02	5.58 ± 0.03	0.50 ± 0.02	1.84 ± 0.02	12.23 ± 0.02	2.77 ± 0.03	77.10 ± 0.04	361.48 ± 0.47
Control - O 16 WAP	95.59 ± 0.01	4.41 ± 0.01	0.36 ± 0.01	1.79 ± 0.03	7.45 ± 0.02	2.72 ± 0.03	83.27 ± 0.03	366.12 ± 0.13
Sample + Benomyl 8 WAP	93.67 ± 0.32	6.34 ± 0.31	0.30 ± 0.03	2.08 ± 0.12	10.50 ± 0.02	2.58 ± 0.03	78.21 ± 0.26	357.50 ± 1.27
Sample + Benomyl 16 WAP	96.20 ± 0.03	3.82 ± 0.02	0.42 ± 0.03	1.93 ± 0.03	11.35 ± 0.04	2.61 ± 0.02	79.86 ± 0.06	368.66 ± 0.36
Sample + Tecto - 40 8 WAP	94.41 ± 0.46	5.61 ± 0.47	0.75 ± 0.02	2.72 ± 1.54	11.34 ± 0.05	2.96 ± 0.03	77.58 ± 0.42	362.49 ± 2.00
Sample + Tecto 40 16 WAP	96.53 ± 0.15	3.47 ± 0.15	0.42 ± 0.02	1.70 ± 0.03	13.54 ± 0.02	2.92 ± 0.02	77.95 ± 0.16	369.71 ± 0.76

Mineral composition and Anti-nutritional Factors (mg/100g)

Six different elements and three anti-nutritional factors were analyzed for concentrations (mg/100g) in dry weight basis. The results of the comparative analysis showed that nitrogen content at Benomyl applied 8_WAP (1.68), Benomyl at 16_WAP (1.82) and Tecto-40 EC at 8_WAP (1.82) were not significantly different. However, Tecto-40 EC at 16_WAP, the nitrogen content increased (2.17); the same was observed for phosphorus which significantly increased to 10.20 at 16_WAP with Tecto-40 EC. The magnesium content at Benomyl 8_WAP and Benomyl 16_WAP (1.84 and 1.23) were similar to that observed in Tecto-40 EC 8_WAP and Tecto-40 EC 16_WAP (1.84 and 1.23). The sodium content at Tecto-40 EC 8_WAP (1.34) and Tecto-40 16_WAP (1.35) were significantly higher than that observed in Benomyl 8_WAP (0.90) and Benomyl 16_WAP (0.63).

The anti-nutritional factor tannin was not significantly different in the four treatments. However, phytate at Tecto-40 EC 8_WAP (56.99) and Tecto-40 EC 16_WAP (56.47) were much higher in Benomyl 8_WAP (49.49) and Benomyl 16_WAP (50.11). Oxalate was much lower in Tecto-40 EC treated samples (Tecto-40 8_WAP 45.34 and Tecto-40 EC 16_WAP 45.55) when compared with Benomyl 8_WAP (49.85) and Benomyl 16_WAP (50.19).

Table 2: Mineral compositions and anti-nutritional factors (mg/100g) of Benomyl and Tecto-40 EC treated and non-treated cocoyam samples.

Samples	Nitrogen (N)	Phosphorous (P)	Potasium (K)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Tannin	Phytate	Oxalate
Control - O 8 WAP	1.96	9.60	9.20	5.01	1.23	0.88	0.48	56.35	49.66
Control - O 16 WAP	1.19	7.50	7.03	8.02	1.23	1.03	0.43	56.71	48.87
Sample + Benomyl 8 WAP	1.68	8.70	7.73	9.02	1.84	0.90	0.43	49.49	49.85
Sample + Benomyl 16 WAP	1.82	9.00	8.55	7.02	1.23	0.63	0.45	50.11	50.19
Sample + Tecto - 40 8 WAP	1.82	8.70	9.13	4.01	1.84	1.34	0.53	56.99	45.34
Sample + Tecto 40 16 WAP	2.17	10.20	5.15	7.02	1.23	1.35	0.50	56.47	45.55

DISCUSSION

The relative low moisture content determined in this study can be helpful for the storage of cocoyam tubers at ambient temperatures. The high crude protein content of the cocoyam samples as revealed in the study can be considered as a good attribute since it is mainly consumed by resource poor farmers. The results of crude fibre content showed that the cocoyam tubers could be a good source of dietary fibre. The low crude fat content observed in the study indicates that cocoyam is a low fat crop, and thus would contribute less to the health problems related with excess fat intake. The high total ash content is an indication that the food crop is rich in minerals. Both the carbohydrate and gross energy content of the food crop were high, and thus can be regarded as rich foods with high energy value.

The study showed that both the Benomyl and Tecto-40EC treated cocoyam were rich in both the minerals and phytochemicals. Consumption of nutrient rich foods such as cocoyam would help the body to utilize protein, carbohydrate and other nutrients.

The anti-nutritional factors (tannin, phytate and oxalate) were significantly lower than those reported from other regions. The environment could be a contributing factor. However, various studies have shown that the processing methods such as boiling, fermentation roasting, etc, can significantly reduce anti-nutritional factors to low levels.

CONCLUSION

This study has shown that the use of some selected fungicides can help in controlling the diseases of cocoyam that lead to yield loses, and that cocoyam would play a significant role in alleviating the household food insecurity and periodic food shortages existing in some families inhabiting cocoyam growing areas.

RECOMMENDATION

More detailed analysis including processing, sensory testing and determining the antioxidants from extract of this food crop are suggested for further investigation in order to obtain healthful and comfortable cocoyam products.

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Evaluation of selected herbicides for zero tillage production of maize (*zea mays*)

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ABSTRACT
The experiment was conducted between the months of June to September 2021 in Igboora to evaluate the effectiveness of selected herbicides for weed control in zero tilled plots for the cultivation of maize. The experiment was arranged in a randomized complete block design consisting of five treatments and three replicates. The treatments were three herbicides (Glyphosate, Gramoxone and United force) and two tillage methods (Minimum and Conventional tillage). Data were collected on the growth, yield parameters of maize and on the effectiveness of these herbicides on weeds. All growth, yield parameters of maize and weed parameters measured were significantly influenced at 5% level of probability using DMRT. The highest yield was observed on the conventional tilled plots (6853.3kg/plot) similarly weed biomass was significantly high in conventional tilled plots (23.3g), however it can be observed that, given increasing dearth of cheap labor for conventional tillage, the use of glyphosate should be encourage for zero tillage production of maize since it is less labour intensive and has high yield return when compared to other herbicides.
Key words: Glyphosate, Gramoxone, United force, Minimum tillage, Convectional tillage

INTRODUCTION
Cereal is the most widely cultivated and consumed crops globally (Enyisi et al 2014), of all these cereals, maize remains the most popularly grown and consumed in all ecological zones of the country (Iken et al 2002). In Nigeria, specifically in the Northern part of the country, maize provides a major food resource for both man and animal and as major source of energy and protein in their diet. Maize is the most important cereal crop in Nigeria ranking second behind sorghum in the number of people that feeds on it (Enyisi et al 2014). Maize is a multipurpose crop, provides food and fuel for human being and feed for animals (poultry and livestock) (Enyisi et al 2014).
The production of maize (zea mays) is increasing globally and this trend is evident throughout central Europe and Africa, we may expect this trend to continue in the future (Tatsumi *et al* 2011). Maize is the third most important staple food in the world today and a staple food of great socio – economic importance in sub- Sahara Africa (Pamodh Sharma et al 2018). At the present time, maize is the most significant crop in the world next to wheat and rice. Weed management has major effect on the

success of maize productivity because the competition ability of maize is relatively low. Weeds are a constant source of concern for the successful growth and development of this crop. They compete with crops for light, moisture, space and nutrients and consequently interfere with normal growth of the crop.

Weed control is important in maize cultivation; the critical period of weed interference is influenced by the competing weed species, the cultivars, plant density and environmental factors such as light, water, nutrient and allelopathy (Shrestha *et al* 2018)). Weed interference not only results in crop losses but also increases insect pest damage, harvesting difficulties and crop contamination. It is generally conceded that the recurrent economic damage to agriculture from weeds surpasses the more incidental damage inflicted by insect pest rodents and diseases (James, et al 2000). The nature of weed interference influence strongly the choice of weed control measures to be adopted which could either be chemical, cultural or biological weed management. Chemical weed controls are increasingly being used in Nigeria and other developing countries because it offers an effective and relatively inexpensive means for managing weed problems.

MATERIALS AND METHODS

Experimental site.

The experimental plot was located at the Teaching and Research farm of Oyo state college of Agriculture and Technology, Igboora (Latitude $7^0$40N and Longitude $3^0$30E).

Land preparation and plot layout

The land was slashed manually and debris packed. There were 15 plots each measuring 3m by 3m and 1m between plots.

Sowing of seed was done at a spacing of 75cm by 50cm.Three (3) seeds were planted per hole and later thinned to two (2) plants per stand to make a total plant population of 53.333 plant/ha

Experimental design.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. The treatments include: (i). Glyphosate applied at 4.1 liters/ha (ii). Gramoxone applied at 4.1 liters/ha (iii). United force applied at 4.1 liters/ha which was done one week after the slashing and clearing the plot. The minimum tillage and conventional tilled plots were weeded manually at 3rd and 5th weeks after planting. N.P.K 15:15:15 fertilizer was applied at 5g per stand at 3rd and 5th week after sowing. At flowering stage of the crop the plots rouged after the data for weed population and biomass had been taken. This was to allow for complete harvesting.

Data collection

The agronomic parameter taken on the plants include Germination % at 5days after planting by visual counting which was calculated as $\frac{\text{number of seeds germinated per bed}}{\text{Total number of seed sown per bed}} \times \frac{100}{1}$.

Plant height was measured using a meter rule at four weeks after sowing (4WAS) and at flowering stage. Leaf area was measured at (4WAS) and at flowering stage using the formula (Lx B) 0.75. Weed population biomass was also taken at (4WAS) and at flowering stage using 0.25/ 0.25 quadrant for measurement, Number of days to flowering was done by counting, Number of days to 50% flowering was done by counting, Weight of seeds per cob was measured on a sensitive scale and Stem diameter was measured using Vanier caliper at flowering stage.

Data analysis

All the data collected were subjected to analysis of variance (ANOVA) and significant means separated using Duncan multiple range tests (DMRT).

RESULTS AND DISCUSSION

Table 1: Effects of herbicides on the germination and growth performance of maize

		Plant height (cm)		Leave area (cm)		Stem diameter
Herbicides	Germination (%)	4WAP	At Flowering	4WAP	At Flowering	At flowering
Glyphosate	92.3a	57.0a	181.2b	34.2ab	712.1a	2.1ab
Gramoxone	88.6a	56.5a	162.3b	19.3b	481.5a	1.9bc
United force	82.9a	41.3b	158.4b	29.0ab	467.4a	2.0bc
Minimum tillage	88.6a	53.5a	159.6b	32.1ab	552.4a	1.8c
Convectional tillage	90.5a	64.7a	231.3a	39.2a	772.1a	2.3a

Means followed by the same letter are not significantly different from others at 5% level of probability using Duncan's Multiple Range Test (DMRT)

Effects of herbicides on the germination and growth performance of maize

It was observed in table 1, that there was no significant difference in maize germination percentage across the treatments though the plant height was significantly affected by the treatments. At the flowering stage, significant difference was observed between the conventional tillage and other treatments. It was also observed that the conventional tillage significantly affected the plant leaves area (39.2cm) similarly the conventional tillage had significant effect on the stem diameter of the plant.

Table 2: Effects of herbicides on the yield parameters and yield of maize

Herbicides	**Numbers of days to flowering**	**Numbers of days to 50% flowering**	**Numbers of seeds per cob**	**Weight of seeds per cob (g)**	**weight of 100 seeds (g)**	**Seed yield (kg/ha)**
Glyphosate	53.0c	57.7c	419.1b	98.7a	23.6a	5264.0ab
Gramoxone	55.3b	60.3b	365.9b	89.1b	23.0a	4752.0b
United force	58.3a	63.0a	368.6b	71.6b	21.0a	3818.6b
Minimum tillage	55.3b	59.7b	412.3b	97.5b	23.6a	5200.0ab
Convectional tillage	52.0c	56.0c	531.6a	128.5a	24.2a	6853.3a

Means followed by the same letter are not significantly different from others at 5% level of probability using Duncan's Multiple Range Test (DMRT)

Effects of herbicides on the yield parameters and yield of maize

The result in Table 2 shows that there is significant difference in the number of days to flowering among all the five treatments. Conventional tillage and glyphosate were the first to flower (52days) which is significantly faster than gramoxone and minimum tillage (55days). The highest number of seeds per cob (531.6 seeds) was produced from conventional tillage which was superior to other treatments. The least number was produced from gramoxone treated plot (365.9 seeds). There was significant difference between the treatments in respect to the weight of 100 seeds, conventional tillage produced the heaviest seeds (24.2g) as against united force (21.0g). Conventional tillage produced also had the highest maize seed yield (6853.3kg/ha) while plot treated with united force had least seed yield.

Table 3: Effects of herbicides on weed population and biomass

	weed density ($N_0/0.25m^2$)		**weed fresh weight ($g/0.25m^2$)**		**Weed biomass at flowering ($g/0.25m^2$)**
Herbicides	4WAP	At Flowering	4WAP	At Flowering	
Glyphosate	2.0ab	2.3ab	12.0b	118.5a	20.0a
Gramoxone	2.3a	3.0a	12.3b	92.3a	18.3a

United force	1.3b	2.7ab	20.0a	124.5a	21.7a
Minimum tillage	1.3b	2.7ab	9.7b	101.6a	21.7a
Convectional tillage	1.3b	2.0b	10.3b	105.5a	23.3a

Means followed by the same letter are not significantly different from others at 5% level of probability using Duncan's Multiple Range Test (DMRT).

Effects of herbicides on weed population and biomass

The result in table 3 shows the effect of herbicides on weed population and biomass, it can be observed that at 4WAS the weed density of plots treated gramoxone (2.3/0.25m^2) were significantly high while the least value (1.3/0.25 m^2) was observed on plots treated with united force, minimum tillage and conventional tillage. After flowering conventional tillage had the least weed density (2.0/0.25m^2) which is however similar to other treatments except gramoxone (3.0/0.25m^2) which had high weed density after flowering. The value of weed fresh weight at (4WAS) were similar among the treatments except united force (20.0g) however at flowering stage there was significant difference among all the treatments which significantly had higher value. It was also observed that weed biomass at flowering stage was similarly not affected by the treatments.

CONCLUSION

It can be concluded from the study that conventional tillage and glyphosate had the best effect on growth and yield performance of maize, it was also observed that united force caused delay in growth and reduced the yield performance of maize in the study area, thus glyphosate herbicide is recommended for zero tillage of maize production since it is less laborious when compared to conventional tillage system.

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Growth and pod weight of jute mallow (*Corchorus olitorius*) to moringa leaf extract and NPK 15:15:15 fertilizer application in Igboora, Oyo State, Nigeria

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ABSTRACT
A screen house experiment was conducted to evaluate growth and fresh pod weight of *Corchorus olitorius* using moringa leaf extracts and NPK 15:15:15 fertilizer. Moringa leaf extracts were extracted from moringa leaves using standard procedures. Corchorus seeds were sown into 20 experimental pots containing 8 kg of topsoil each. The seedlings were thinned to one seedling per pot after a week. Treatments were applied at 2 weeks of sowing in five replicates arranged in a complete randomized design (CRD). The seedlings were treated separately with 20ml foliar application of moringa leaf extracts (ethanol and water extractions) at 2 and 4 weeks after sowing; NPK 15:15:15 side-dressed at 100 kg/ha and control (untreated). Data were collected on plant height, number of leaves, stem diameter, leaf area and fresh pod weight on weekly basis from the 4th week after sowing to the 9th week. Data were analysed using Analysis of Variance and significant means were separated using Duncan Multiple Range Test at $p \leq 0.05$. Both NPK 15:15:15 and moringa leaf extracts enhanced the growth of corchorus. However, NPK 15:15:15 at the rate of 100 kg/ha gave the highest significant results in all the growth and yield parameters considered in this study. NPK 15:15:15 gave the highest significant plant height, number of leaves, stem diameter, leaf area and pod weight of 34.20cm, 33.20, 3.76mm, 35.80cm^2 and 15tonnes/ha respectively compared to other treatments and the control. Since, moringa is readily available and cheaper to obtain by the farmers in the study area, the extracts can be used by corchorus farmers when NPK15:15:15 is unavailable and the cost becomes uneconomical to boost the growth and yield of corchorus.
Keywords: Corchorus; Moringa; NPK; Growth and Yield

INTRODUCTION
Jute Mallow (*Corchorus olitorius*) is a popular leafy vegetable (Dansi *et al.*, 2008). It is an erect annual herb that varies from 60 cm to approximately 150 cm in height depending on the cultivar. The leaves and young fruits are used as a vegetable (Plants for a future, 2012). However, the crop yield is in serious decline due to low fertility soil, poor yield, pest and diseases. In traditional farming systems, low quantity of fertilizer is applied, but, Jute mallow responds well to fertilization, particularly

nitrogen (Ogunrinde and Fasinmirin, 2011). However, excessive and indiscriminate use of chemical fertilizers leads to soil degradation and imposes a serious threat to human health (Fujimoto, 1998). In the study area, jute mallow is cultivated on a small scale, so that the production cannot pay back the cost of purchase and transportation of mineral fertilizers, hence the need of alternative sources of fertilizer is important for sustainable production.

However, organic waste could be viable alternative to chemical fertilizers. Organic farming has enough positive impacts: the long-term productivity in soil conservation and improvement of soil fertility involves the sustainability of production for future generations and environmental impact. Moringa is suitable for intense production of many crops due to its growth hormone activity (Foidl *et al*., 2001). Moringa leaf extract can be used as foliar spray to increase plant growth (Rady *et al*., 2015). Moringa contains zeatin, a plant hormone derived from the purine adenine. It is a member of the plant growth hormone family known as cytokinins (Howladar, 2014). These plant hormones help cell division, differentiation, growth, protect against oxidation and help in nutrient assimilation. However, there are limited reports on the frequency of application of the moringa leaf extract and its impact on crop productivity in the study area.

The major constraint to increased corchorus production in the study area are low soil nitrogen and the non-availability of mineral fertilizer at the right time of farming to augment the soil nutrient deficiency and even when available most peasant farmers cannot afford it. Therefore the objective of this study was to evaluate the effects of moringa leaf extract and NPK 15:15:15 fertilizer on growth and yield of jute mallow.

MATERIALS AND METHODS

The experiment was carried out at the Screen house of Department Crop Production Technology, Oyo State College of Agriculture and Technology, Igboora, Oyo State. Igboora is in a derived savanna zone located (Latitude 7^0 26'1"N and Longitude $3^0$17'16"E) in Ibarapa Central Local Government Area of Oyo State. The region has two distinct seasons. The dry season is usually from November to March and wet season is from April to October. Also, the average high temperature of the region is 33 °C, while the average low temperature is 22 °C (weatherspark.com).

Composite soil samples were taken from the topsoil collection site at 0-20cm depth, air dried and passed through 2mm sieve and were sent to the laboratory to determine the physical and chemical properties of the soil. The pH was determined with pH meter and available phosphorus was estimated using Bray and Kurtz, 1945 method. Macro-Kjeldahl method was used to assess the total nitrogen of the soil (Jackson, 1958) and exchangeable Ca, Mg, K, Na and effective cation exchange capacity C.E.C in soil by use of atomic absorption spectrophotometer (Tel and Hargerty, 1984).

Fresh moringa leaves were collected from a moringa farm in Igboora town, thoroughly washed and air dried at room temperature. The dried leaves were pounded using pestle and mortar, kept in a well labeled sampling bag and taken to the laboratory for nutrients extraction. The ethanol extraction was done using the method of Makkar and Becker (1996). Moringa leaf powder (20g) was weighed and added to 675ml of ethanol in a 2.5 L Winchester bottle for 24 hours. Also, aqueous extraction was carried out using the method of Bashir *et al*. (2014). Fresh leaves (1kg) was weighed and added to 200ml of distilled water for 24 hours. The extracts were taken to the laboratory to analyze the chemical compositions of the solutes.

Corchorus seeds used for the study were collected from National Horticultural Research Institute (NIHORT) Ibadan. The seeds were sown directly into 20 experimental pots containing 8kg soil each at three seeds per pot before they were thinned down to one seedling per pot a week after sowing. The pot experiment was arranged in a completely randomized design (CRD), containing four treatments viz: - ethanol moringa leaf extract (EMLE), aqueous moringa leaf extract (AQMLE), NPK 15:15:15 fertilizer and the control in five replicates. Foliar application of EMLE and AQMLE was also done at the rate of 20ml 2 and 4 weeks after sowing.The application of NPK 15:15:15 fertilizer was done at the standard rate of 100kg/ha according to (Aluko, 2014) at 2 weeks after sowing (WAS) using side-dressing method. The control had no application of fertilizer or moringa extract. Data were collected from 4th to 9th WAS on weekly basis on the following growth parameters. The plant height was collected using measuring tape, leaf area (the length and breadth of the widest leaf) using measuring tape, number of leaves through visual counting, stem diameter using vernier caliper and fresh pod weight using measuring scale. The data collected were subjected to Analysis of Variance (ANOVA) and significant means were separated by Duncan Multiple Range Test at 5% level of probability using STAR, 2.0.1 (2014) version software package.

RESULTS AND DISCUSSION

Pre cropping soil analysis

The chemical and physical properties of the soil used for the experiment shows a pH value of 6.47 (Table 1) indicating that the experimental soil was slightly acidic. The soil is low in essential plant nutrients like nitrogen, phosphorus and potassium with values of 0.17%, 5.97mg/kg and 0.36cmol/kg respectively. These values were below the critical values of soils in the derived savanna ecological zone (Adeoye and Agboola, 1985).

Table 1: Physico-chemical composition of experimental soil

Element	pH (H_20)	Ca^{2+} (cmol/kg)	Mg^{2+} (cmol/kg)	K^+ (cmol/kg)	Na^+ (cmol/kg)	ECEC (cmol/kg)	Total N (%)	Av. P (mg/kg)
Value	6.47	3.65	0.76	0.36	0.54	5.34	0.17	5.97

Chemical composition of ethanol and aqueous moringa leaf extracts

Essential nutrients nitrogen, phosphorus and potassium were present in the EMLE and AQMLE. The composition of nitrogen, phosphorus and potassium in the EMLE were 11.68mg/100g, 5.24mgkg^{-1} and 4.20Cmolkg^{-1} respectively, while that of AQMLE were 4.10mg/100g, 1.20mgkg^{-1} and 1.83Cmolkg^{-1} respectively. Also, Zeatin and Giberrellin are present as natural growth enhancer with 4.94mg/100g and 2.80mg/100g respectively in EMLE and 2.83mg/100g and 1.90mg/100g respectively in AQMLE (Table 2).

Table 2: Chemical compositions of moringa leaf extracts

Elements	N	P	K	Zeatin	Giberellin
Ethanol moringa leaf extract (mg/100g)	11.68	5.24	4.20	4.94	2.80
Aqueous moringa leaf extract (mg/100g)	4.10	1.20	1.83	2.83	1.90

Growth responses of corchorus to moringa leaf extracts and NPK 15:15:15

The plant height of *Corchorus olitorius* responded differently to the treatments. There were significant differences P≤0.05 in the plant height of corchorus from fourth to ninth, weeks after sowing (WAS). Also at 9 WAS, corchorus treated with NPK 15:15:15 gave highest significant P≤0.05 plant height (34.20cm) than other treatments and the control with 22cm (Table 3). Also, different responses in the number of leaves of corchorus were observed amongst the treatments. There were significant differences P≤0.05 in the number of leaves of Corchorus from the fifth to ninth weeks, after sowing. At 7 WAS, Corchorus treated with NPK 15:15:15 gave highest significant P≤0.05 number of leaves of 33.20 than other treatments and the control with 18.40 (Table 3).

Moreover, the treatments showed significant P≤0.05 variations in corchorus stem diameter all through the experimental duration. At 9 WAS, corchorus plants treated with NPK 15:15:15 gave highest significant P≤0.05 stem diameter of 3.76mm than aqueous moringa leaf extract and the control of 1.51mm (Table 3), but was not significantly different from ethanol moringa leaf extract. There were significant differences P≤0.05 in leaf area of Corchorus from the fourth to ninth weeks, after sowing. At 9 WAS, corchorus plants treated with NPK 15:15:15 gave highest significant P≤0.05 leaf area of

35.80cm^2 than aqueous moringa leaf extract and the control with 19.80cm^2 (Table 3), but was not significantly different from ethanol moringa leaf extract.

Table 3: Effects of moringa leaf extracts and NPK 15:15:15 on growth responses of corchorus

TREATMENTS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS
			Plant height (cm)			
NPK	27.40a	31.40a	32.20a	33.60a	33.60a	34.20a
EMLE	22.80b	26.00ab	27.40ab	28.40ab	28.80ab	28.20ab
AQMLE	19.80bc	20.40b	21.00cb	21.20bc	21.40bc	21.40bc
CONTROL	15.20c	18.20c	18.40c	18.80c	19.00c	20.00c
			Number of leaves			
NPK	12.20a	29.20a	32.40a	33.60a	32.40a	33.20a
EMLE	12.20a	26.00ab	28.60ab	28.80ab	29.40ab	29.60ab
AQMLE	11.80a	20.60bc	23.60b	25.60b	25.60b	27.00b
CONTROL	12.40a	15.20c	15.20c	18.60c	17.60c	18.40c
			Stem diameter (mm)			
NPK	2.90a	3.16a	3.17a	3.19a	3.49a	3.76a
EMLE	2.54a	2.65ab	2.62ab	2.87ab	3.01ab	3.11a
AQMLE	1.98b	2.08b	2.12b	2.12bc	2.14bc	2.46a
CONTROL	1.91a	0.87c	0.97c	1.06c	1.37c	1.51c
			Leaf area (cm^2)			
NPK	24.40a	26.00a	32.60a	32.80a	34.00a	35.80a
EMLE	23.40ab	25.60a	28.00a	29.00ab	32.80a	23.40a
AQMLE	12.30bc	24.60a	22.60ab	21.00b	30.80a	13.60bc
CONTROL	8.20c	11.60c	12.60b	14.60d	17.20c	19.80a

Means with the same letter are not significantly different.

EMLE- Ethanol Moringa Leaf Extract at the rate of 20ml 2 and 4 WAS, AQMLE - Aqueous Moringa Leaf Extract (AQMLE) at the rate of 20ml 2 and 4 WAS, NPK- NPK 15:15:15 at the standard rate of 100kg/ha at 2 WAS, CONTROL- No application. WAS= Weeks after sowing.

Effects of moringa leaf extracts and NPK 15:15:15 on fresh pod weight (tons/ha) of corchorus

There was significant difference P≤0.05 in the fresh pod weight of *Corchorus olitorius* at ninth WAS. All the fruits collected were weighed weekly and the summed up. *Corchorus olitorius* treated with NPK 15:15:15 gave highest fresh pod weight of 15 tonnes/ha and was significantly higher (P≤0.05) than other treatments and the control of 2.01 tonnes/ha (Table 4).

Table 4: Effects of moringa leaf extracts and NPK 15:15:15 on fresh pod weight (tons/ha) of corchorus

TREATMENTS	9 WAS
NPK	15.00a
EMLE	9.28b
AQMLE	5.11c
CONTROL	2.01d

Means with the same letter are not significantly different at (P≤0.05)

The application of moringa leaf extracts and NPK 15:15:15 influenced the growth and fresh pod weight of corchorus. The significant increase in growth and fresh pod weight of corchorus treated with NPK 15:15:15 was due to the high levels of essential macro nutrients (nitrogen, phosphorus and potassium) present in the inorganic fertilizer than the moringa leaf extracts. This is because nitrogen, phosphorus and potassium are required for optimum growth and yield of crop. However, moringa leaf extracts increased the growth and fresh pod weight of corchorus than the control. This is because of the presence of Zeatin and Gibberellins which are growth enhancers present in the moringa leaf extracts. This is in line with Hala and Nabila (2017) who reported that Zeatin increased the yield of crop by 25 to 30% and Palada (1996) reported that foliar application of moringa leaf extracts increased the yield of peanut, soybean, sorghum and tomato.

CONCLUSION

It can be concluded that NPK 15:15:15 and moringa leaf extracts enhanced the growth and fresh pod weight of corchorus. Therefore the use of inorganic and organic fertilizers to boost growth and yield of the crop is of high importance. However, the application of NPK15:15:15 at the rate of 100 kg/ha gave the highest results in the growth parameters considered in this study. The high levels of nitrogen, phosphorus, potassium, Zeatin and Gibberellin present in the ethanol moringa leaf extract gave significant effects on the growth of the crop compared to the aqueous moringa leaf extract and the control. The results also indicated that Zeatin and Giberellin are the growth enhancers present in moringa leaf extract. However, moringa is readily available and cheaper to obtain by the farmers in the study area, and the extracts can be used by corchorus farmers when NPK15:15:15 is unavailable and the cost becomes uneconomical.

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Effect of some fungicide-based seed treatments on the emergence and early morphological traits of cashew (*Anacardium occidentale* L.) seedlings.

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ABSTRACT

Cashew (*Anacardium occidentale* L.) seedlings are most times raised in the nursery and propagated by seed. Cashew seedlings are attacked by fungi diseases such as damping off and seedling blight caused by fungi such as *Fusarium spp*. and *Rhizoctonia spp*. which can amount to about 60-65% loss in the nursery. Cashew nut seeds are majorly sown by farmers untreated with fungicide-based seed dressings. Fungicides have also been observed to delay seedling emergence and negatively influence morphological traits. This experiment aims at observing the effect of using fungicide seed dressings on cashew seedling emergence and early morphological traits. Medium cashew nut biotype and three commonly used fungicide-based seed dressing's trade names which are; Seed Care, Dress Force and Apron Star were used using the recommended rate of 10g of fungicide/4kg of nuts on the label of each fungicide. The four weeks experiment was set up in a nursery using a Completely Randomized Design CRD. The treatments are; Control + Medium (CT+M); Apron Star + Medium (AS+M), Dress Force + Medium (DF+M) and Seed Care + Medium (SC+M). 2mm sieved topsoil using 25 cm by 12.5 cm nursery bags were used. The experiment was replicated thrice. Data were collected on the emergence and morphological traits which were analyzed using Analysis of Variance (ANOVA) by using GenStat statistical software while treatment means were separated using Least Significant Difference (LSD) at ($P \leq 0.05$). A significant difference was only observed at 28 DAS with AS+M (100%) and DF+M (100%) emerging as the best. A significant difference in stem girth was only observed between the control treatment CT+M ($0.63 cm^2$) and AS+M ($0.77 cm^2$). It could be deduced that the use of selected common fungicide-based seed dressing treatments can be used in preventing prevalent nursery fungi diseases without causing a delay in the emergence and negative impact on the morphology of young cashew seedlings

Key: Cashew; Seedling; Nursery; Seed dressing; Fungicide; Emergence.

INTRODUCTION

In Nigeria and other tropical nations around the world, cashew (*Anacardium occidentale* L.) is a tree crop of significant commercial importance (Ezeagu, 2002). It is a tough and drought resistant tree crop cultivated for its apple and most importantly the nut in Nigeria and other growing countries (Adeigbe *et al*., 2015). Commercial cashew plantations are established in various agro-ecologies of

Nigeria for cash earnings and sustainable income generation (Umeh, 2007) which has brought about an expansion in the land area cultivated in Nigeria.

Cashew is mostly propagated by seed (Yeboah *et al*., 2020) which is usually raised in the nursery for a recommended period of 2 to 3 months before transplanting to the field (Hammed *et al*., 2012). An encouraging and successful establishment of crops in the field has a direct effect on seedling performance in the nursery (Brown, 1984). Fungi which is a common pathogen of cashew in the nursery must be controlled as well as the use of dry, clean and insect free seeds to enhance vigourous and healthy cashew seedlings (Akos *et al*., 2017).

The health of cashew plants, including growth and nut yield in terms of quality and quantity, are severely compromised by diseases, which constitute a huge biological constraint to the plant (Kolawole *et al*., 2021). More than 10 common diseases of cashew are caused by fungi (Cardoso *et al*., 2013). Common fungi diseases of cashew at the seedling stage include damping-off, seedling blight, root rot, dieback and seedling wilt which constitute as high as 60-65% loss in the nursery as damping-off is the most prevalent constituting 15-20% of the losses (Hammed, 2015). Some important fungi disease causing pathogens includes *Phytophthora spp*., *Pythium spp*., *Rhizoctonia spp*., *Fusarium spp*. and *Cylindrocladium scoparium* (Dar *et al*., 2011).

Some seed dressing fungicide trade names commonly used in the nursery or on the field in Nigeria include Apron Star, Apron Plus, Forte Plus and Dress Force. Seed dressing treatments are not only known to control fungi diseases and pathogens but could also stimulate good plant performance and vigour (Yakubu *et al*., 2011).

Cashew seedling loss in two commercial nurseries caused by fungi diseases in the south-western part of Nigeria with a loss of about 80% to 85% facilitated the need to incorporate the use of fungicide-based seed treatments to prevent fungi diseases and also raise healthy seedlings. Most cashew farmers in Nigeria do not utilize agrochemicals to grow their cashew but are often used by researchers for experimental purposes (Aminu *et al*., 2021). Investigation of cashew farmers revealed that dressing cashew seeds with fungicide-based treatments are not a common practice in Nigeria as farmers believe cashew seed is a hardy seed and does not need dressing before planting. Seed dressing has been observed to be responsible for delay in germination, affects early morphological traits, interferes with yield in some arable crops and could however enhance their performance (Yakubu *et al*., 2011). It is therefore important to study the effect of the selected fungicide-based seed treatments on cashew seedling emergence and early morphological traits. Therefore, the objective of this study is to identify differences in using fungicide seed dressing on cashew seedlings' emergence and early morphological traits.

METHODOLOGY

The four weeks experiment was set up in July 2022 to August 2022 in a commercial nursery at Akinyele local government area of Ibadan, Oyo State. The experiment was laid in a Completely Randomized Design (CRD) with four treatments replicated thrice using the medium (4g-8g) cashew nut biotype and three commonly used fungicide-based seed dressings which are; Seed Care (Imidacloprid 10% + Thiram 10% WS), Dress Force (Imidacloprid 20% + Metalaxyl-M 20% + Tebuconazole 2% WS) and Apron Star (200g/kg Mefenoxam + 20g/kg Difenoconazole + 200g/kg Thiamethoxam WS) applied using the recommended rate of 10g of fungicide/4kg of nuts on the label of each fungicide. A control treatment was established where no fungicide was applied along with the other fungicide applied treatments. The treatments are; Control + Medium (CT+M); Apron Star + Medium (AS+M), Dress Force + Medium (DF+M) and Seed Care + Medium (SC+M). Sieved topsoil with a 2mm sieve was used in raising the cashew nuts planted using one nut per 25cm by 12.5cm perforated nursery polythene bag. The perforation of the nursery bags is to allow the drain of excess water that could promote fungi development and seed rot. The seeds were sown at 4cm depth and watering was done every 48 hours. Data on daily emergence % from the onset of the first noticeable emergence for four weeks were collected and morphological data on plant height (cm), stem girth (mm), leaf area (cm^2) and the number of leaves and seedling vigour (5-Excellent, 4-Good, 3-Fair, 2-Poor and 1-Bad) were recorded at four weeks after sowing. Data collected were subjected to Analysis of Variance (ANOVA) and analyzed using SAS 2010 Package while means were separated using DMRT at (0.05%) probability level.

RESULTS AND DISCUSSION

The emergence of cashew seedlings was first observed 13 days after sowing (DAS) but records were only taken between 14 to 28 DAS when emergence seems to have stopped according to Mog *et al*., (2017) as shown in Table 1. This emergence data agrees with Mog *et al*., (2017) who also observed that cashew seedling emergence starts as early as 12 DAS while emergence stops around 28 DAS. Percentage emergence was only comparable among the treatments at 28 DAS as shown in Table 1. Uniform % emergence of 25% was observed at 14 DAS. Emergence increased across the treatments at 16 DAS with AS+M and DF+M having the highest emergence of 66.70% each while both the control treatment CT+M and SC+M had 50% emergence each. At 18 DAS increase in emergence was also observed across the treatments when compared with 16^{th} DAS. AS+M (83.30%) had the highest emergence followed by DF+M (75%), SC+M (66.70%) and the control treatment CT+M (58.30%). No increase in emergence was observed at 20 DAS when compared with 18 DAS while only DF+M increased at 22 DAS to 100% from the previous 75%. This implies that DF+M was the first among the treatments to reach 100% emergence. This observation contradicts Yakubu *et al*., (2011) report that generally, seed dressing can cause a delay in emergence. CT+M (66.70%) and AS+M (91.70%) only increased in emergence at 24 DAS while CT+M (75%) only increased in emergence at 26 DAS. At the end of the emergence data reading at 28 DAS, AS+M and DF+M both had 100% emergence while the control treatments CT+M and SC+M both had 75% emergence. This result indicates that the application of the selected fungicide-based treatments on cashew nuts before sowing did not influence emergence negatively. A significant difference was observed between CT+M (75%) and AS+M (100%) and also between CT+M (75%) and DF+M (100%).

Table 2 shows the report of the early morphological parameters of the treatments 28 DAS. No significant difference was observed in plant height, the number of leaves, leaf area and seedling vigour though the control treatment CT+M (17.10cm) had the shortest plant height while SC+M (19.30cm) had the tallest plant height. AS+M (6.7) had the least number of leaves followed by CT+M (7), DF+M (7.2) and SC+M (8.3) which had the highest. The control treatment CT+M (56.60 cm^2) recorded the smallest leaf area while DF+M (62.60cm^2) had the largest leaf area. The treatments all had a relatively above good seedling vigour score. A significant difference in stem girth was only observed between the control treatment CT+M (0.63 cm) and AS+M (0.77 cm). However, CT+M had the smallest stem girth when compared with the other treatments. The result of these early morphological parameters indicates that the application of seed dressing fungicides on sown cashew nuts did not affect cashew seedlings negatively. This result also contradicts the general observation of Yakubu *et al*., (2011) that the application of fungicide-based seed dressings can negatively affect early morphological traits.

CONCLUSION

The application of the seed dressing fungicides did not delay cashew seedling emergence. Emergence was the same when comparing sown untreated nuts with nuts treated with Seed Care fungicide. Apron Star and Dress Force fungicides both gave improved emergence than untreated sown nuts and Seed Care fungicide treated nuts. The fungicide treated seedlings had taller plant height, stem girth and leaf area than the untreated cashew seedling though the overall seedling vigour showed no notable variation among the treated and the untreated seedlings. From this experiment, it could be said that the use of the selected common fungicide-based seed dressing treatments can be used in preventing common nursery fungi diseases without any negative impact on the emergence and plant morphology. However, a repeat of this experiment is encouraged in validating this result and also, the effect of these selected fungicide-based seed treatments should be checked on other cashew nut biotypes and when sown in situ.

Table 1: **Cashew seedling treatment emergence table from 14 to 28 days after sowing (DAS).**

	% EMERGENCE							
Treat	**Day 14**	**Day 16**	**Day 18**	**Day 20**	**Day 22**	**Day 24**	**Day 26**	**Day 28**
CT+M	25.00	50.00	58.30	58.30	58.30	66.70	75.00	75.00
AS+M	25.00	66.70	83.30	83.30	83.30	91.70	91.70	100.00
DF+M	25.00	66.70	75.00	75.00	100.00	100.00	100.00	100.00
SC+M	25.00	50.00	66.70	66.70	66.70	66.70	66.70	75.00
Grand Mean	25.00	58.30	70.80	70.80	77.10	81.20	83.40	87.50
LSD ($P \leq 0.05$)	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**24.97**

Key: CT+M= Control + Medium; AS+M= Apron Star + Medium; DF+M= Dress Force + Medium; SC+M= Seed Care + Medium. ns = not significant

Table 2: Morphological parameter table of the treatments at 28 days after sowing (DAS).

	EARLY MORPHOLOGICAL PARAMETERS				
Treat	**Plt.Ht (cm)**	**No.Ls**	**St.Grth (cm)**	**L.Area (cm^2)**	**S.Vig**
CT+M	17.10	7.0	0.63	56.60	4.2
AS+M	18.00	6.7	0.77	58.70	4.3
DF+M	18.10	7.2	0.67	62.60	4.2
SC+M	19.30	8.3	0.73	57.10	4.2
Grand Mean	18.10	7.3	0.70	58.70	4.2
LSD ($P \leq 0.05$)	**ns**	**ns**	**0.10**	**ns**	**ns**

Key: CT+M= Control + Medium; AS+M= Apron Star + Medium; DF+M= Dress Force + Medium; SC+M= Seed Care + Medium; Plt.Ht = Plant Height; No.Ls = Number of Leaves; St.Grth= Stem Girth; L.Area= Leaf Area; S.Vig= Seedling Vigour. ns = not significant

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Review of Pathology Issues Due to Respiration and Dormancy in Storage

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ABSTRACT

Yam is one of the preferred staple foods in West Africa. The annual vegetative cycle of yam necessitates a long period of storage to make it available all year round. The major problems of yam tuber storage are dormancy which triggers sprouting, respiration and transpiration, which cause weight and quality losses and, expose the yam tubers to pathological issues. This work reviewed the effects of yam dormancy and respiration on yam tubers in storage, and how they affect the nutritional and other qualities of stored yam tubers thereby exposing them to pathological issues. Results of this review work on stored yam tubers showed that the methods which can help in controlling yam dormancy to reduce sprouting in storage, minimize respiration in stored yams to reduce weight loss and rot development will go a long way to increase the storability of yams tubers in storage.

Key words: Respiration, Dormancy, vegetative, sprout, transpiration

INTRODUCTION

Yam (Dioscorea spp.) are monocotyledonous plants belonging to the family *Dioscoreaceae* and genus Dioscorea. Over 600 species are identified but only six are important in Africa, Southeast Asia, and South America. The economically important species are *D. rotundata, D. alata, D. cayenensis, D. bulbifera, D. dumetorum, and D. esculenta* (Hahn 1995).

Yams produce edible subterranean or aerial tubers that form the organ of economic importance. The tuber is important chiefly as a staple food, providing nourishment to people in the tropics and subtropics. Depending on the specie, it is particularly rich in carbohydrate, containing 50–80% starch/dry weight. Other constituents of high nutritional values are vitamins C and B6, potassium, iron, manganese, and amino acids; contents of sodium and saturated fats are low. More than the daily adult requirement of vitamin C can be obtained from yam even after losses from cooking have been subtracted (Bell 1983). Also, the combination of high potassium and low sodium makes yam potentially important in protecting people against osteoporosis and heart-related diseases. Worldwide, as many as 5 million hectares of land are put to yam cultivation and about 49 million tonnes of the crop are produced with 94% of this value being grown in West and Central Africa (FAO 2005). In West Africa, consumption/capita/day ranges from 258 kcal (in Nigeria) to 364 kcal (in

Bénin Republic). Indeed, yam is so important that it has a place in festive occasions, rites, and taboos of the people. Agriculturally, the tuber is important as it is the source of planting material.

Planting materials

Cultivation is mainly by vegetative propagation using the whole tuber or pieces of it (setts). Planting is done between late January and April in West Africa coinciding with the start of the rains, although early plantings in November–December are known in areas where there are swamp land areas. Irrespective of when planting is done, vine emergence occurs about the month of February and beyond,. Tubers are initiated from 30 days after vine emergence and these are formed underground in most species including *D. rotundata*. However, some species, such as *D. alata*, produce aerial tubers. Flowering occurs 40 to 90 days after vine emergence (Ile *et al*., 2006) depending on the planting date. In yam, therefore, growth is dependent on yam dormancy as the farmer must wait for yams to break dormancy before planting them but tuber development commences during early growth.

Harvesting of yam

Tubers become mature for harvest as early as 6 months after vine emergence, corresponding to about the month of August. Early harvested tubers have very high moisture content and so are prone to deterioration from diseases. Also, they have a bland taste after being cooked. The main harvesting season falls between the months of November and January of the following year, coinciding with the onset of shoot senescence and the start of the dry season. These tubers are larger, morphologically more mature, have a higher dry matter content and lower moisture, a lower susceptibility to deterioration, and better cooking and nutritive qualities than those from an early harvest. After harvest and during storage, sprouting begins. Sprouting tends to occur at a definite period of the year, coinciding with the onset of the rains. Hence, the duration to sprouting varies from 30 to 150 days, depending on harvest date, species, and storage conditions. Tubers harvested early in the season spend a longer time in storage before sprouting occurs. Though the onset of sprouting is welcomed by the farmer who desires to commence planting, it marks the start of physiologically and pathologically induced deterioration and eventually the loss of food quality. The period during which yam tubers will not grow, even if put under ideal conditions for growth, is referred to as the dormant period and such tubers are said to be dormant.

Preservation as relates to white yam

Preservation refers to the process of treating foods to preserve them much longer in storage. It is the act of applying a physical or chemical treatment to food items to protect and maintain their nutritional contents and avoid food deterioration or spoilage over time. The shelf-life and shelf-stability of food are extended by food preservation. It also protects the food from dangerous bacteria and enzymes that might affect human health, promotes longer shelf life, and encourages availability of convenience foods, such as ready-to-serve beverages and instant mixes (Olaoye and Oyewole, 2012). It is important to understand how yam tubers change during storage. In the context of this presentation, it is important to give some background insight of the pathological events that take place in storage during yam preservation and we infer that yam preservation commences from the point of harvest and dormancy.

The concept of dormancy, tuber respiration and implication for storage

According to Lang *et al* (1987) dormancy is a temporary growth arrest of any plant part containing a meristem. It is the period during which yam tubers will not grow, even if put under ideal conditions for growth. . It is an inherent plant physiological mechanism that regulates the timing of sprouting of affected plant part. The dormancy period can also be defined as the period of reduced endogenous metabolic activity during which the tuber shows no intrinsic bud growth, although it retains the potential for future growth. It is highly influenced by genetic and evolutionary constituents and also affected by environmental factors such as; temperature, moisture, oxygen, and CO_2 content of the storage atmosphere (Ile 2004). Dormancy has been classified into three categories based on the factors that influenced growth arrest (Lang *et al* .,1987). These include: Endodormancy (this is a deep dormancy during which growth arrest is influenced by internal physiological and genetic factors within the meristem), Para-dormancy (this occurs due to growth arrest by physiological factors external to the meristem), and Eco-dormancy (growth is stopped by unfavorable external or environmental factors). The consequence of dormancy is severe for yam preservation system because the duration of dormancy is very long; as many as 270 days, depending on the time of tuber harvest and the definition of the start of dormancy (Hamadina 2011). Another perspective to this phenomenon buttresses that dormancy in yam tubers occurs in the following phases: the long phase I of dormancy (the period from tuber physiological maturity to the formation of tuber germinating meristem(TGM), which is up to 200 days). Phase II is the period from TGM to the initiation of foliar primordium-IFP, which is about 40 days long. Thirdly, a short phase the period from IFP to the physical appearance of shoot bud (ASB) on the surface of the tuber, which is only about 10 days (Ile 2004). In principle, increasing the period under Phase I (TGM) as highlighted above would be useful in developing yam genotypes with an increased period of dormancy. Though the onset of sprouting is welcomed by the farmer who desires to commence planting, dormancy breakage marks the start of physiologically and pathologically induced deterioration and eventually the loss of food quality (Hamadina 2011). Dormancy helps to maintain organoleptic quality during storage (Ovono *et al.*, 2010).

Yam tubers are living. It takes or breathes in oxygen from the air and uses it inside its body, in this case the fleshy interior. Breathing process involves that the tuber must give off air that is used. Secondly, to stay alive the tuber must “eat” or nourish itself by consuming a tiny part of its stored food. In this process the yam gives off heat and moisture as wastes. The entire process of breathing in air and consuming its stored food and then giving off used air carbon dioxide, heat and moisture is called respiration (Panneerselvam *et al.*, 2007). Good and safe storage of yam tuber requires that the tuber should respire slowly.

The aforementioned dormancy and respiratory dynamics is manipulated to confer storage elongation and pathological through the following protocols. These protocols evolved from rich indigenous knowledge of farmers. A practice that time has perfected but currently under threat with climate change scenarios.

Knowledge gained from different works in the past has made it much easier to relate the effects of treatments on dormancy to specific physiological states, the phases of dormancy. In the past, conclusions on the control of yam tuber dormancy were difficult because of the inability to relate the effects of plant growth regulators (PGRs), and other effects, to any physiological state. The findings of Hamadina (2011) has stimulated the establishment of more in-depth explanations of the mechanism controlling tuber dormancy, such as the effects of PGRs on subcellular activities relating to the progress towards appearance of shoot bud. The work also forms a base for effective studying and analyzing dormancy in yam species and other root and tuber crops exhibiting dormancy.

Pathological issues emanating from dormancy and respiration in yam

Causes of storage losses of yam tubers include dormancy (time length of sprouting), respiration, transpiration, rot due to fungi and bacteriosis, insects, nematodes and mammals (Passam *et. al*., 1978). Sprouting, transpiration and respiration are physiological activities which depend on the storage environment mainly temperature and relative humidity. These physiological changes affect the internal composition of the tuber and result in destruction of edible material, which under normal storage conditions can often reach 10% after 3 months, and up to 25% after 5 months of storage (Passam et. al., 1978). The dry matter portion of yam tubers is mostly composed of carbohydrates, which exist primarily in the form of starch and sugars (Ikediobi and Oti 1983). A study conducted on the chemical composition of yam tuber stored under ambient and cold room condition showed no significant differences between the means obtained for carbohydrate, fat and fiber after 72 hours of storage (Afoakwa and Sefa-Dedeh, 2001). Onyeme and Idowu (1988) studied physical and chemical changes that occur on yams stored in traditional barns. Their result shows losses in moisture, dry matter, crude protein and ascorbic acid after 120 days of storage. Consequently they recommended that farmers should not store yam tubers for a period longer than 120 days as this exposes the yams to pathological issues, loss in qualities and market value.

CONCLUSION

Generally, it can be concluded that all the methods that can help in managing dormancy and respiration on yams in storage such as good ventilation, high relative humidity and reduced light can help in reducing weight loss, drying, rotting and other pathological issues. This study shows unmanaged dormancy and high rate of respiration can cause reduction in quality of yams and expose them to attacks by pests and diseases during the storage period.

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Effects of Poultry Manure and NPK Fertilizer on Turmeric performance in Guinea Savanna zone of Nigeria.

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ABSTRACT

A research study was carried out in June 2021 to investigate the productivity index of Turmeric using poultry manure (PM) and NPK 15.15.15 in Kogi State University Anyingba. Treatments consisted of poultry manure, NPK 15:15:15 fertilizer and the combination of poultry manure and NPK with two varieties of turmeric (*Curcuma xanthorhiza* and *Curcuma longa*). There were eight treatments combination laid out in a complete randomized design block (RCBD). NPK fertilizer and poultry manure were applied at 400 kg/ha and 6 tonnes/ha respectively after weeding at 4 WAP. The result showed that the plots that received either poultry manure or its combination with NPK had significantly higher values of number and weight of rhizome than the control check. X+0 gave 19.0 and 0.89 kg on number and weight of rhizome respectively in *Xanthorhiza* variety, the same trend also occurred in *longa*. Harvest index was remarkably low on the zero application of X+0 (45.27%) and L+0 (45.27%) than other treatments. PM produced the highest leaf dry weight of *Xanthorhiza* species (0.30 kg), while its combination with NPK gave the highest value (0.30 kg) in *longa*. Higher yield was obtain in a single application of PM than single application of NPK15:15:15 but considerable high yield was achieved in the combination of both PM +NPK than the single application. Poultry manure + NPK produced highest yield of 15.6 t/ha in *C xanthorhiza* and 12.05t/ha in *C longa* resulting to 43 and 62% increase in yield over the control respectively. Therefore, to avert the high cost of NPK organic fertilizer and achieve a superior effect in terms of balanced plant nutrient in Anyingba, It is recommended that combination of Poultry manure and NPK fertilizer is required for optimum production of turmeric.

INTRODUCTION

Turmeric (*Curcuma longa* L Lam*)* is one of the underutilized crop species, it is an herbaceous perennial belonging to the family *Zingiberaceae* and a native of south Asia particularly India (Ouma and Jeruto, 2010). The plant is propagated from rhizomes, the leaves are long, broad, lanceolate and bright green. The flowers are pale yellow and borne on dense spikes. The pseudo stems are shorter than leaves and require a warm and humid climate (Ouma and Jeruto, 2010). Turmeric thrives in different types of soils ranging from light black loam, red soils to clayey loams. The production and nutritional values of these turmeric are limited due to the low fertility of native soils in most parts of Nigeria (Law-Ogbomo *et al*., 2012).The potentials of organic manure for improving crop yields in agriculture are widely recognized (Nwaogu *et al.*,2005).

However, differences exist in the quality of organic amendment materials which can considerably influence the levels of some organic compounds formed in plants thereby impacting on the biochemical and physiological process of the plant product. The use of inorganic fertilizer to increase the yield has been found to be effective only within few years, demanding consistent use on long-term basis (Ojeniyi *et al.*, 2009). The hazardous environmental consequences and high cost of inorganic fertilizers make them not only undesirable but also uneconomical and out of reach of the rural farmers who still dominate the Nigerian agricultural sector (Shiyam *et al*., 2011). Poultry manure has been reported to contain more plant nutrients than all other organic manures (Ali, 2005).The use of chemical fertilizers and organic manure has both positive and negative effects on plant growth and the soil. Chemical fertilizers are relatively expensive, have high nutrient contents, and are rapidly taken up by plants. There is a need to determine the independent influence of poultry manure and inorganic fertilizer such as NPK on the growth, yield, and nutritional quality of fast-growing turmeric as to justify the continuous mixture of both or otherwise. There is a dearth information on the use of chemical fertilizers and poultry manure on turmeric production in Anyingba Kogi state. The objective of the work is to determine the effect of poultry manure and NPK on yield and performance of turmeric.

MATERIALS AND METHODS

This study was carried out between June and November 2021 at the botanical garden of the department of Plant Science and Biotechnology, Faculty of Natural sciences, Kogi State University, Anyingba which lies between longitude 7.5˚N and latitude 6.9˚E with an altitude of 420 meters above sea level. The site is known with a suitable atmospheric condition, having an annual mean rainfall and temperature of 1250 mm and 25˚C respectively. The vegetation is typical of derived savannah with a sandy soil (Ifatimehin, 2009). The experimental site was cleared of the existing vegetation, cleared and bed were made manually with hoe.

Each bed represented a plot of 2 m × 2 m. The plots were marked out into three (3) replicates with eight treatments combinations laid out in a complete randomized block design (RCBD). Plant spacing was 50 cm x 30 cm. The treatments were as follow; two varieties of Turmeric (*Curcuma xanthorhiza* and *Curcuma longa*), NPK fertilizer 15-15-15 and poultry manure. The treatments combination were; *C. xanthorhiza* + Control (no fertilizer); *C. xanthohriza* + Poultry manure; *C. xanthorhiza* + NPK *C. xanthorhiza* + NPK + Poultry manure; *C. longa* + Control (no fertilizer); *C. longa* + Poultry manure; *C. longa* + NPK + Poultry manure and *C. longa* + NPK. NPK 15-15-15 fertilizer was weighed out as recommended rate of 400 kg/ha (Olojede *et al*,2007) while poultry manure was applied at 6 tonnes/ha (Nwokocha *et al*,2005) the treatments were applied at 4 weeks after planting (4WAP).Weeding and other cultural practices were done as at when due. Growth and yield data were collected and subjected to analysis of variance (ANOVA) (SPSS Program, version 20 SPSS Inc., Chicago, IL, USA for computer package). The differences between the treatments were compared using Duncan Multiple Range Test (DMRT). Values of P less than 0.05 ($P \leq 0.05$) were taken as significant.

RESULTS AND DISCUSSION

The result showed that the plots that received either poultry manure or its combination with NPK had significantly higher values of number and weight of rhizome than the control check (Table1). X+0 gave 19.0 and 0.89 kg on number and weight of rhizome respectively in *Xanthorhiza* variety, the same trend also occurred in *longa*. Harvest index was remarkably low on the zero application of X+0 (45.27%) and L+0 (45.27%) than other treatments.

In table 2, PM produced the highest leaf dry weight of *Xanthorhiza* variety (0.30 kg), while its combination with NPK gave the highest value (0.30 kg) in *longa*. Tiller dry weight responded more to organic manure and combination with NPK in both varieties. The treatments have no effect on the dry matter.

The highest yield in t/ha was obtained in combination of PM +NPK, this occurred in both varieties. The *C. xanthohriza* variety produced 15.6 t/ha while the *C. longa* gave 12.05 t/ha resulting to 43 and 62% increase in yield over the control respectively. This also reflected in harvest index where the lowest value was obtain in zero application (control) of X+0 (45.27) and L+0 (48.60). The yield components responded more on the combination of PM and NPK, although single application of PM produced more values than single application of NPK. This resulted due to excellent soil amendment performance of PM that provides nutrients for growing crops and also improves soil quality when applied wisely, because it has high organic matter content combined with available nutrients for plant growth (Van Ryssen *et al*., 1993).The harvest index showed optimal yield efficiency in all the treatments except the control, this revealed that poultry manure in combination with NPK is an indicator to yield efficiency and productivity. This agrees with the work done by Kour *et al*. (2014) and Obasi *et al.* (2021) that reported that yield and harvest index could be influenced by organic and inorganic soil amendment.

CONCLUSION /RECOMMENDATION

The application of organic and inorganic fertilizer to turmeric has significant effect on the yield components which also lead to a high yield in t/ha obtained during the study. Harvest index was significantly higher in all the treatments than the control. The experiment showed that high yield was obtained in a single application of PM than single application of NPK 15:15:15 but considerable higher yield could be achieved in the combination of PM +NPK than their single application. In conclusion, to avert the high cost of NPK fertilizer, it is recommended that combination of Poultry manure and NPK fertilizer is used to achieve a superior effect in terms of balanced plant nutrient and for optimum production of turmeric in Anyimgba Kogi .

Table 1: Effect of different Fertilizer applications on some yield traits of Turmeric

Treatments	Number of Rhizomes	Weight of Rhizomes	% Moisture content	Harvest Index
X+O	19.00 ± 1.73c	0.89 ± 0.19c	69.57 ± 6.58	45.27 ± 6.75c
X + NPK	29.00 ± 2.00bc	1.20 ± 0.29ab	67.93 ± 3.82	62.17 ± 14.13b
X + OM	36.33 ± 5.68bc	1.58 ± 0.58a	69.57 ± 4.30	61.87 ± 5.94b
X+OM+NPK	40.33 ± 26.08b	1.21 ± 0.76ab	71.23 ± 1.42	74.17 ± 10.79a

L+O	39.33 ± 5.50bc	0.46 ± 0.02d	72.10 ± 2.50	48.60 ± 16.02c
L+ NPK	44.00 ± 7.21b	0.52 ± 0.12cd	71.27 ± 3.82	62.50 ± 15.32b
L + OM	85.67 ± 12.05a	0.95 ± 0.09c	67.93 ± 3.82	57.63 ± 13.70b
L + OM+NPK	26.50 ± 5.50bc	1.56 ± 0.06a	69.60 ± 0.00	78.95 ± 3.25a
			NS	

Values are mean ± standard deviation. Values with different alphabets are significantly different at p ≤ 0.05 seperated by Duncan multiple range test. NS: Not significantly different. X = Xanthorhiza: L = longa

Table 2 : Effect of Poultry manure and NPK fertilizer on the Yield and Yield components of Turmeric

Treatment	**Leaf Dry Weight**	**Tiller Dry Weight**	**Dry Matter**	**Yield (T/ha)**
X+O	0.21 ± 0.02ab	0.17 ± 0.01c	0.28 ± 0.03	8.87 ± 1.97bc
X + NPK	0.25 ± 0.07ab	0.20 ± 0.03bc	0.27 ± 0.02	12.03 ± 2.95ab
X + OM	0.30 ± 0.09a	0.23 ± 0.07bc	0.28 ± 0.02	15.80 ± 5.89a
X+OM+NPK	0.27 ± 0.04ab	0.27 ± 0.08ab	0.29 ± 0.01	12.05 ± 2.95ab
L+O	0.18 ± 0.00b	0.17 ± 0.04c	0.29 ±0,01	4.60 ± 0.17c
L+ NPK	0.21 ±0.03ab	0.17 ± 0.02c	0.29 ± 0.02	5.17 ± 1.19c
L + OM	0.27 ± 0.07ab	0.23 ± 0.06bc	0.27 ± 0.02	9.50 ± 0.87bc
L + OM+NPK	0.30 ± 0.01a	0.32 ± 0.04ab	0.28 ± 0.01	15.57 ± 0.55a
			NS	

Values are mean ± standard deviation. Values with different alphabets are significantly different at p ≤ 0.05 separated by Duncan multiple range test. NS: Not significantly different. X= Xanthorhiza; L= longa

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Evaluation Of Advanced Orange Fleshed Sweetpotato (Ofsp) Genotypes For High Root Yield Dry Matter Content And Response To Biotic Stress

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ABSTRACT
Sweetpotato is cultivated in all the States in Nigeria including the Federal Capital Territory. However, there are traits preferred by Users., evaluation of advanced orange fleshed sweetpotato genotypes was carried out at the Western Experimental field of National Root Crops Research Institute (NRCRI), Umudike in Southeastern Nigeria in 2021 cropping season with the objectives to: select sweetpotato genotypes for high storage root yield, response to biotic reaction and high dry matter content attributes necessary for sweetpotato cultivation and consumption. Data collected were on: total fresh storage root yield in t/ha, total number of storage roots per genotype per plot, mean storage roots per plant and storage flesh colour and dry matter content. Data collected were analyzed using analysis of variance. The storage flesh colour was compared using sweetpotato colour chart while data on biotic stresses were rated on a Scale of 1 to 9. Results indicated that 60% of the sweetpotato lines had mean storage root weight of above 8.0t/ha and mean number of roots between 1.5 to 9.2 per plant. This indicated that the OFSP genotypes are high yielding. Their dry matter content ranged from 28 to 30.0% which is acceptable to sweetpotato consumers as high dry matter content gives good taste. It is therefore recommended that although some genotypes seem to be immune/resistant to sweetpotato virus infection, more work is required to better classify these genotypes with respect to their reaction to virus as some symptomless genotypes in the trial may have escaped infection. Also more work is required for the high yielding sweetpotato genotypes for immediate multi-location testing for selection of superior genotypes with high dry matter that will be acceptable to the end-users.

Key words: orange fleshed, sweetpotato, dry matter, high root yield, biotic response and attributes

INTRODUCTION
Sweetpotato is an important food crop for Nigerians. The crop is cultivated in all the States in the country including the FCT (Federal Capital Territory, Abuja). It plays important role in the diets of Nigerians where it is used as fast food by Super Markets and Road side food vendors in Nigerian cities, University campuses. In food industries it is used for making flour, cakes, chips, doughnuts and bread. Starch for textile industries, the leaves are used for dying clothes, fodder for animals and leafy vegetables for human consumption. The flour can be stirred in hot water into thick paste for use as swallow or in other food supplements like in cooking beans.

About 84,000 hectares is devoted to sweetpotato cultivation annually in Nigeria with 65% production from the northern part of the country, 25% production from the eastern part of the country particularly Ebonyi, Anambra and Enugu States while 10% production could be from Western part of the country especially Kwara State (FAOSTAT, 2022). Most of the sweetpotato storage roots produced from the country is consumed within the country with less than 1.0% for export to surrounding western African countries. The consumption rate of sweetpotato in the country is steadily increasing as a result of much pressure on cassava (Okpara, 2008). The crop is a short duration crop with only 4 months duration in the field. Its rate of cultivation turnover is faster when compared with other root and tuber crops. (Yam 7 to 12 months duration in the field, cassava 7 to 12 months duration in the field, cocoyam 12 months in the field (Okpara, 2008).

The average yield of storage roots of the crop in farmers field is only 6t/ha. This low yield is attributed to low yielding of varieties and late maturing of local landraces that farmers are cultivating (Gurmu et al., 2017). Other constraints in sweetpotato cultivation are sweetpotato virus disease complex, sweetpotato storage root weevils (Cylas Spp) and the inability of the sweetpotato to tap nutrients from the low soil fertility (Gasura, et al., 2008).

Nigerian farmers grow a wide range of sweetpotato landraces which have been selected by farmers over time Haris et al., 2020). These landraces came from sources such as chance seedlings and introductions from neighbouring countries. These varieties have accumulated high loads of viral diseases in their system which has led to low yields in both storage roots and in foliage (Arituaet al 1993). These landraces have low dry matter which is associated with culinary qualities acceptable by consumers, however, these landraces are also susceptible to sweetpotato virus diseases (SPVD) caused mainly by sweetpotato feathery mottle virus (SPFMV). SPVD complex is an important sweetpotato production constraint in Nigeria especially for the orange fleshed variety (Wambugu, 1991). The objective of this study is to screen sweetpotato genotypes at the Advanced Yield Trial for high storage root yield, response to biotic reaction (sweetpotato storage root weevil, leafspot, virus diseases) and dry matter content attributes necessary for sweetpotato cultivation and consumption**.**

A total of 30 genotypes were evaluated in a randomized complete block design with three replications at the Western experimental field of NRCRI, Umudike. Each genotype was planted on a $9m^2$ plot at a spacing of 100cm between ridges and 30cm between plants and planted on the crest of the ridges. A virus susceptible variety (UMUSPO/3) and a national variety (TIS87/0087) were included in the trial as Check varieties**.**. The planting materials from all the clones were healthy four node seed vine cut from the terminal portion of healthy sweetpotato mother plants and were planted on the ridges with at least two nodes of the seed vine inserted into the soil.

The sweetpotato crop was weeded at 4 WAP (Week After Planting). Other subsequent weeding were hand pulling of tall weeds that would otherwise block the sweetpotato plants from receiving maximum sunlight necessary for photosynthesis for storage root bulking. Harvesting took place 150 days after planting. At harvest the following data were collected: mean total fresh storage root yield in t/ha, mean total number of storage roots per genotype per plot, mean storage roots per plant and storage flesh colour. Also noted were storage dry matter content which was determined by oven drying of 100g of fresh sample at 80^0C for 48 hours. Data were also collected on virus severity, leafspot and storage weevil infestation. Data on storage components were subjected to analysis of variance and the storage flesh colour was compared using sweetpotato colour chart while data on biotic stresses were rated according to Toker et al (1999). Virus symptoms were scored at 2 and 3 MAP (Months After Planting), on a Scale of 1 to 9. Where 1.0 means no symptom and 9.0 means plant almost dead with disease. Disease assessment was carried out using 1-9 disease severity (DS) rating scale as suggested by Toker *et al*. (1999).

Where:
1 = Immune , 2 = Highly Resistant, 3 = Resistant, 4 = Moderately Resistant, 5 = Tolerant, 6 = Moderately susceptible, 7 = Susceptible, 8 = highly susceptible, 9 = highly susceptible.

RESULTS AND DISCUSSION

The result of 30 sweetpotato genotypes on mean number of storage roots, total weight of fresh roots, storage root dry matter content and size of storage roots of sweetpotato genotypes and their reactions to biotic stresses are presented in Table 1.

Table 1: Mean number, fresh, dry matter and size of storage roots of sweet potato genotypes and their reactions to biotic stresses

Genotypes	No. of storage root /plot	No. of storage / plant	Mean fresh weight of storage root (t/ha)	Mean storage root size (>100g)	% dry matter content	Flesh colour	Weevil damage score (1 -9)	SPVD reaction (Score 1 – 9)	Leafspot reaction (Score 1 – 9)
87/OP/195	143	9.2	40.4	178.0	30.2	Orange	1.0	1.0	1.0
NWAOYO RIMA	92	4.2	27.4	158.0	30.0	White	1.0	1.0	1.0
NSPO/2012 /066	98	5.2	23.5	159.0	29.0	Orange	1.0	1.0	1.0
PO3/6	117	3.7	18.0	160.0	28.0	orange	1.0	2.2	1.0
Tio-Joe/OP/322	100	4.5	19.3	127.0	30.4	Orange	1.0	1.0	1.0
PO3/31	101	3.2	19.8	130.0	28.0	D /O	1.0	1.0	1.0
PO3/119	97	4.8	18.7	138.0	28.3	D/O	1.2	1.0	1.0
PO3/8	80	2.0	18.9	164.0	29.2	D/O	1.0	1.0	1.0
NWA/OP/239	79	4.2	18.8	165.0	30.2	orange	1.0	1.0	1.0
NWA/OP/23	83	3.0	18.7	114.0	30.1	orange	1.0	1.0	1.0
87/OP/123	85	5.6	18.8	143.0	30.1	orange	1.0	1.0	1.0
PO3/31	97	4.2	18.8	135.0	30.2	D/O	1.0	1.0	1.0
87/OP/215	70	4.1	17.8	121.0	28.1	D/O	1.0	1.0	1.0
PO3/136	84	3.2	17.3	150.0	30.2	D/O	1.0	2.3	1.0
NSPO/2012 /06	103	5.2	17.9	143.0	28.6	D/O	1.0	1.0	1.0
NSPO/2012 /1068	84	4.0	17.9	154.0	30.1	D/O	1.0	1.0	1.0
PO3/37	94	5.2	16.5	143.0	28.2	D/O	2.3	1.0	1.0
NWA/OP/253	98	4.1	16.4	124.0	28.2	l/orange	1.0	1.0	1.0
PO3/116	86	4.2	15.9	150.0	30.1	D/O	1.5	1.0	1.0
87/OP/65	79	4.5	15.8	167.0	28.2	L/orange	2.1	1.0	1.0
NWA/OP/230	78	4.0	15.8	168.0	28.3	orange	1.0	1.0	1.0
PO3/32	93	4.2	12.7	104.0	29.1	D/O	1.0	1.0	1.0
PO3/85	97	4.0	11.3	131.0	29.1	D/O	1.0	1.0	1.0
87/OP/175	99	4.4	11.2	137.0	30.2	D/O	1.0	1.0	1.0
PO3/39	81	4.7	10.9	136.0	29.1	D/O	1.3	1.0	1.0
PO3/18	96	3.8	10.8	130.0	28/1	D/O	1.0	1.0	1.0
NSPO/2012 /068	103	4.2	10.6	138.0	29.1	orange	1.0	1.0	1.0
NSPO/2012 /187	77	5.6	10.7	125.0	28.3	orange	1.2	1.0	1.0
TIS87/0087	42	1.5	8.7	131.0	36.2	cream	1.2	1.0	1.0
UMUSPO/3	48	3.8	9.6	130.0	29.9	D/O	1.3	8.3	1.0
Range	1-117	0-9.2	0-40.0	2.0-178	10-36.2	=	=	=	=
Mean	89.5	3.8	15.2	141.8	=	=	1.1	1.3	1.0
S.E	9.6	3.9	4.0	12.1	=	=	=	=	=
Prob level	P<0.01	P<0.01	P<0.01	P<0.01					

Note: D/O = Deep Orange

The number of storage roots produced by each of the genotypes varied significantly (p<0.01) and ranged from 0 to 9.2 plant per 1000/ha with the Check varieties producing less number of storage root of 1.5 (Tis87/0087) and 3.2 roots (UMUSPO/3) respectively less than the improved genotypes as per yield with mean of 3.8 per plant/1000plants/ha. This number of storage roots per genotypes indicated the potential yield per plant of each of the sweet potato genotypes. The number of storage roots produced by the genotypes is used by the farmers to assess high yielding genotypes. The number of storage roots enable the farmer to estimate the number of piece meal harvests the subsistent farmer may intend to do. The higher the number of storage roots, the higher the fresh weight yield of the sweet potato genotypes. High storage yielding sweet potato has a role to play in food security, creation of employment opportunities and poverty alleviation as well as export crop (Ogundele et al. 2008).

The mean performance of the sweetpotato genotypes with fresh storage root yield above 8.0t/ha is presented in Table 1. The total fresh storage root weight varied significantly (p<0.01) and ranged from 10.7 to 40.4t/ha. According to Henderson et al (1997) sweetpotato yield over the years are not stable as they are subjected to environmental effect. These genotypes yielded more fresh root weight than the two Check varieties UMUSPO/3 (with yield of 9.6t/ha and TIS87/0087 with yield of 8.7t/ha. About 40% of the genotypes were low yielding since genotypes yielding less than 10t/ha is regarded as low yielding variety, while up to 60% yielded above 10.0t/ha which indicated that many of the F1 sweetpotato generation at the Advanced Yield Trial were high yielding. (Ajiboye et al., 2008). Sweet potato genotypes suitable for cultivation must have high fresh matter yield across all agro-ecologies. Large scale production of these genotypes could further enhance food sufficiency in the country, and trigger economic revitalization and alleviation of poverty as the benefit trickle down from the farmer to middlemen to large scale or small sale business owners down to consumers.

The dry matter content of 60.0% of the genotypes was above 28.0%, which indicated that these genotypes would possess acceptable taste. This is because good sweetpotato taste is associated with high dry matter content. Also sweetpotato genotypes with high dry matter content would yield high starch and flour for industrial uses such as making of baby foods (Caetano, 2017).

Pathological reactions: Of the high yielding F1 advanced sweetpotato genotypes, only PO3/6 with virus score of 2.2 and PO3/36 with virus score rating of 2.3 presented mild virus symptoms while the rest of the genotypes in the field appeared immune. The susceptible Check variety (UMUSPO/3) was severely infected which indicated that virus infection did occur during the trial and that some of the high yielding genotypes may be immune to virus infection. All the genotypes showed no symptom of leafpot (Alternaria) attack. This indicated that the genotypes may be immune to fungus infection. However, more work is required to better classify these genotypes as immune, resistant or susceptible (Gruneberg et al., 2005; Kiyuva et al., 2020).

Entomological reactions: The following genotypes were mildly attacked by the sweetpotato storage root weevil; PO3/139 with score of 1.3, PO3/119 with score of 1.2, PO3/116 with score of 1.5, 87/OP/65 with score of 2.1 and NSPO/2012/068 with score of 1.2 while the rest escaped attack by the weevil. The harvest took place when the soil was still moist. The mild attack indicated that at the heart of dry period these genotypes would not survive. This is because research showed that sweetpotato storage root weevil is a dry season pest and attack more during dry spell.

CONCLUSION

This study revealed that 60% of the sweetpotato lines had storage root weight of above 8.0t/ha and number of roots between 1.5 to 9.2 per plant. This indicated that the OFSP genotypes are high yielding. Their dry matter content ranged from 28 to 30.0% which is acceptable to sweetpotato consumers as high dry matter content gives good taste. It is therefore recommended that although some genotypes seem to be immune/resistant to sweetpotato virus infection, more work is required to better classify these genotypes with respect to their reaction to virus as some symptomless genotypes in the trial may have escaped infection. Low yielding sweetpotato genotypes are a major constraint to high sweetpotato production and therefore the low yielding genotypes should be discarded. More work is required for the high yielding sweetpotato genotypes for immediate multi-location testing for selection of superior genotypes with high dry matter that will be acceptable to the end-users.

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Multi-Location Trial Of Sweetpotato (*Ipomoea Batatas* (L) Lam*)* Genonotypes Across Different Agro- Ecologies For High Storage Root Yield And Response To Biotic Stresses In Nigeria

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ABSTRACT

Not all sweetpotato genotypes perform better under all agro-ecologies. Based on this, one year trial was conducted in 2021 for multi-location trial of sweetpotato genonotypes across different agro- ecologies for high storage root yield and response to biotic stresses in Nigeria. Twenty five clones were planted in three replications at each site at spacing of 100cm between ridges and 30cm within plants in a plot size of 9m^2 (3m x 3m) in randomized complete block design across ten locations in Nigeria. Data collected include total weight of storage roots in t/ha (TWOSR) weight of commercial in t/ha (CRW), weight of non- commercial roots in t/ha (NCRW) and weight of vines in t/ha (VW). Statistical analysis was carried out using STAT computer package version 9. Analysis of variance was conducted for all the traits to detect significant differences among the clones with the model for a randomized complete block design. The Harvest index was used to select high yielding genotypes per unit area for on-farm trial. Results indicated that the following varieties were selected: 87/OP/195 (34.1t/ha), Cemsa 74-228 (31.0t/ha), PGN16021-39 (26.6T/ha), PGA14011-43 (26.6t/ha), Cri- Okumkom (25.4t/ha), Cri-Apomuden (25.0t/ha), PGA14442-1 (24.2t/ha), PGN17362-N1 (24.0t/ha), PGA14398-4 (24.0t/ha). PGA17265-N1 (23.4t/ha), Cri-Dadanyuie (23.1t/ha) and PGA14351-4 (23.0t/ha). The above genotypes were selected as a result of high harvest index and large storage root weight above their grand mean. The varieties selected could be used as parents in the breeding programme to utilize their good qualities as resistance to biotic stresses for progeny development in Nigeria. These genotypes should be tested further for farmers to make their final selection.

Keywords: multi-location, storage roots, harvest index, progenies and biotic stresses

INTRODUCTION

Sweetpotato is a light demanding crop grown primarily on well drained soils across the country Nigeria (Agbo, 2013). The crop adapt to a wide range of climatic and soil conditions, from the hot windy agro-ecological zone of the north to the colder rainy conditions of the South of the country. In the rain fed Nigeria agriculture, sweetpotato plants are used to provide fodder, control soil erosion on hilly regions, and to supply raw material in form of starch and dye for food and textile industries. Although, having good irrigation facilities, the sweetpotato crop could be cultivated during dry season In southern zones of Nigeria where high rainfall and soil acidity are problems, sweetpotato crop thrive well to earn some income (Nwodo, 2008). Sweetpotato a multipurpose and fast growing crop which provide a wide range of food products and non-food products. The crop is well suited for special purpose such as the establishment of biological control of soil erosion in erosion prone areas of the country and nutrient cycling when the crop dies and decay in low soil fertility areas. The crop is able to grow under erosion prone sites, compacted acidic and saline soils provided the roots have sufficient moisture content. Sweetpotato provide lots of potential in household foods, industry, biomass production for animal fodder (Woolfe, 2002). sweetpotato can be introduced as food crop under diverse climatic and edaphic conditions of Nigeria (Eneji et al., 1995). Sweetpotato food products are high in carbohydrate. The crop is rich in vitamins and minerals in comparison with other roots and tuber crops However, majority of sweetpotato genotypes and their landraces are low yielding. High storage root yielding varieties has high harvest index. According to Nwankwo, I.I.M and O. D. Onyegbula (2021), harvest index refers to the storage root yield per unit area and is defined as the ratio of storage root yield and above ground biomass. Harvest index could be used to select high yielding varieties (Nwankwo, I.I.M and O. D. Onyegbula (2021). One of the limiting factors of sweetpotato landraces are low yield in terms of number of storage roots per stand or in terms of fresh matter accumulation per unit area. The harvest index could be used to select high yielding varieties among the varieties evaluated. Therefore the objectives of this trial were to select superior high yielding storage root genotypes across diverse agro-ecologies in Nigeria for on-farm evaluation to replace old varieties in target environments using harvest index.

MATERIALS AND METHODS

The study was carried out in 10 experimental locations in order to estimate genotype by environment interaction in diverse environments. The locations and their soil description are presented in Table 1:

Table 1: Locations, Environments and Soil types

s/no.	Name of location	Location	Type of environment	Soil type
1	Abia State	Southeast	Rainforest belt	fine- coarse sandy loam
2	Benue State,	North Central	Derived Savanna	Hydromorphic soil
3.	Kwara State	North West	Savanna	
4.	Nasarawa State	North Central	Savanna	Sandy loam
5.	Akwa-Ibom State	South south	Humid Rainforest	Clay soil
6	Anambra State	South east	Derived savanna	Sandy soil
7	Osun State	South west	Rain forest	Clay soil
8	Plateau State	North Central.	savanna	Sandy loam
9	Kano State	North Central	Savanna	Clayey soil
10	FCT, Abuja	North Central	Savanna	Sandy clay loam

The fields were disc- ploughed, harrowed and ridged before planting to achieve a minimum tillage. No application of herbicides. The sweetpotato genotypes from CIP platform in Ghana were raised and multiplied in nursery. The genotypes comprised of 16 clones from CIP, 6 from NRCRI Umudike and 2 national Checks and one from the location where the evaluation was to be carried out. The twenty-five genotypes were planted at ten diverse agro-ecological locations across the country. The twenty five clones were planted in three replications at each site at spacing of 100cm between ridges and 30cm within plants in a plot size of 9m^2 (3m x 3m) in randomize complete block design. Planting was done on the crest of the ridge. Supply of dead seed vine was carried out two weeks after planting in each location. Application of N P K 15:15:15 fertilizer was done 4 weeks after planting as basal fertilizer. Weeding by hoe was done 4 weeks before fertilizer application. Later hand pulling of weeds were carried out in all locations to control post- emergence weeds and to maintain weed- free fields.

Data were collected on: Total weight of storage roots in t/ha (TWOSR) weight of commercial in t/ha (CRW), weight of non- commercial roots in t/ha (NCRW) and weight of vines in t/ha (VW)

Statistical analysis was done with Gen STAT computer package version 2003. Analysis of variance was conducted for all the traits to detect significant differences among the clones with the model for a randomized complete block design. The analysis of variance (ANOVA) was performed on collected data separately for each environment and later combined across locations. The Harvest index was used to select high yielding genotypes per unit area for on-farm trial.

RESULTS AND DISCUSSION

Weight of storage root yield: High significant ($p<0.01$) variation in the storage root yield of the genotypes were observed among the genotypes within the locations and across the locations. However, the performances of The 25 genotypes in the key environment for yield related measurements were compared with their performances over all the 10 locations by ranking. The mean weight of total storage roots, weight of large/commercial roots and weight of small/non-commercial roots are presented in Table 2.

Table 2: Mean total weights of Storage roots and weights of commercial roots and weight of small roots (in parenthesis) of sweetpotato genotypes evaluated in ten diverse Agro-ecologies of Nigeria

Names of variety	Abia	Osun	Abuja	Nasarawa	Akwa-Ibom	Anambra	Benue	Kwara	Plateau	Kano	Mean	Rank
PGA14008-9	32.4 28.4 (4.0)	24.0 18.2 (5.8)	21.0 16.8 (4.2)	12.5 7.9	12.6 7.2 (5.4)	28.3 19.7 (8.6)	**27.9** 18.9 (9.0)	22.0 19.1 (2.9)	25.4 22.3 (3.1)	12.4 11.8 (0.6)	**22.0** 17.0 5.0	1 3

				(4.6)									
OBARE	32.0 19.1 (12.9)	21.0 13.6 (7.4)	25.2 21.1 (4.1)	23.5 15.4 (8.1)	20.4 11.2 (9.2)	10.2 4.0 (6.2)	10.4 5.7 (4.7)	19.5 11.3 (8.2)	20.3 17.2 (3.1)	21.0 13.6 (7.4)	**20.4** 13.2 7.2	16
KWARA	19.5 11.3 (8.2)	14.4 8.3 (6.1)	21.4 9.6 (11.8)	26.4 18.3 (8.1)	10.0 2.0 (8.0)	10.8 4.9 (5.9)	24.7 16.4 (8.3)	24.1 18.6 (5.5)	21.0 18.3 (2.7)	13.9 8.0 (5.9)	**19.0** 12.0 7.0	18
NAN	24.1 18.6 (5.5)	21.5 17.3 (4.2)	27.2 14.4 (13.0)	20.3 17.2 (3.1)	10.8 6.2 (4.6)	18.4 7.0 (11.4)	17.4 14.2 (3.2)	26.6 13.5 (13.1)	24.1 18.6 (5.5)	20.0 13.0 (7.0)	**21.0** 14.0 7.0	15
CRI-APOMUDEN	31.6 23.5 (8.1)	25.2 20.0 (5.2)	26.9 17.7 (9.2)	21.0 18.3 (2.7)	22.3 17.9 (4.4)	28.4 22.9 (5.5)	10.9 5.8 (5.1)	24.2 21.1 (3.1)	26.6 23.5 (3.1)	28.1 19.5 (8.5)	**25.0** 19.0 6.0	6
PG17362-NI	31.4 20.8 (10.6)	24.4 18.1 (6.3)	25.1 19.0 (6.1)	28.5 19.4 (9.1)	21.5 14.4 (7.1)	12.1 9.4 (2.7)	21.2 11.1 (10.1	21.4 9.6 (11.8)	27.4 20.8 (6.6)	27.0 22.0 (5.0)	**24.0** 16.5 7.5	9
87/OP/195	**41.4** 39.8 (1.6)	**36.8** 25.2 (11.6)	**32.1** 26.8 (5.3)	27.6 22.4 (5.2)	**35.6** 29.5 (6.1)	**38.8** 28.6 (10.2)	24.6 13.5 (11.1)	**37.2** 26.4 (10.8)	**34.5** 29.4 (5.1)	**32.0** 23.0 (9.0)	**34.1** 26.5 7.6	1

PGN16021-39	32.8 28.1 (4.7)	25.0 22.8 (2.2)	27.4 19.0 (8.4)	31.5 23.2 (8.3)	20.0 14.0 (6.0)	26.5 21.9 (4.6)	25.1 15.2 (9.9)	25.9 17.7 (8.2)	26.6 22.4 (4.2)	24.8 19.0 (5.8)	**26.6** 20.3 6.3	3
CEMSA 74-228	35.9 23.2 (12.7)	35.0 28.2 (6.2)	29.1 22.5 (6.6)	**35.0** 27.4 (7.6)	32.5 26.2 (6.3)	33.2 21.7 (11.5)	26.6 17.1 (9.5)	24.1 19.0 (5.1)	28.5 23.2 (5.3)	26.1 23.5 (2.6)	**31.0** 23.2 7.8	2
PGA14442-1	25.5 19.9 (5.6)	28.7 21.4 (7.3)	27.6 20.4 (7.2)	23.5 15.6 (7.9)	16.0 10.5 (5.5)	22.3 15.7 (6.6)	24.6 15.1 (9.5)	23.5 15.6 (7.9)	26.4 22.9 (3.5)	24.1 15.5 (8.6)	**24.2** 17.3 6.9	8
BUTTERMILK	15.6 8.8 (6.8)	18.8 13.4 (5.4)	17.9 12.3 5.6)	16.8 11.5 (5.3)	10.7 7.0 (3.7)	15.3 9.8 (5.5)	16.8 9.1 (7.7)	16.6 11.5 (5.1)	12.1 9.4 (2.7)	14.2 9.4 (4.8)	**15.5** 10.2 5.3	23
PGA14011-43	32.5 26.9 (5.6)	33.9 26.6 (7.3)	26.0 17.6 (8.4)	28.2 18.3 (9.9)	19.3 9.6 (9.7)	22.1 18.1 (4.0)	24.5 16.0 (8.5)	28.2 22.3 (5.9)	28.8 18.6 (10.2)	22.0 21.0 (1.0)	**26.6** 20.0 6.6	3
PGA14398-4	30.3 23.4 (6.9)	27.2 21.4 (5.8)	24.3 18.8 (5.5)	27.2 23.6 (3.6)	29.6 18.7 (10.9)	22.2 11.2 (11.0)	9.9 5.4 (4.5)	27.2 13.6 (13.6)	23.5 21.9 (1.6)	17.2 11.5 (5.7)	**24.0** 17.0 7.0	9
CRI-DADANYUIE	30.2 24.8 (5.4)	26.0 19.2 (6.8)	25.2 18.0 (7.2)	28.3 18.6 (9.7)	17.0 1 1.0 (6.0)	26.3 21.7 (4.6)	2.8 1.9 (0.9)	24.3 18.6 (5.7)	26.8 22.9 (3.9)	24.0 19.0 (5.0)	**23.1** 17.6 5.5	11
PGA14372-3	25.3 20.3 (5.0)	26.4 19.2 (7.2)	25.8 21.9 (3.9)	24.1 19.9 (4.2)	23.1 12.1 (11.0)	20.2 16.1 (4.1)	14.4 7.5 (6.9)	22.1 14. 9 (7.2)	20.8 16.4 (4.4)	13.6 9.5 (4.1)	**21.6** 15.8 5.8	14
CRI-OKUMKOM	30.0 25.7 (4.3)	27.3 21.6 (5.7)	21.2 18.4 (2.8)	26.8 22.9 (3.9)	34.0 23.5 (10.5)	31.2 26.1 (5.1)	3.6 2.3 (1.3)	28.6 24.4 (4.2)	24.0 9.6 (14.4)	27.0 22.6 (4.4)	**25.4** 19.7 5.7	5
PO3/35	22.2 18.2 (4.0)	21.2 18.5 (2.7)	7.9 5.6 (2.3)	20.8 16.4 (4.4)	13.9 8.8 (5.1)	19.4 13.7 (5.7)	1.5 0.8 (0.7)	21.8 16.9 (4.9)	28.5 15.3 (13.2)	20.5 13.0 (7.5)	**18.0** 13.0 5.0	20
PGA14351-4	31.2 21.6 (9.6)	20.0 12.0 (8.0)	7.0 4.3 (2.7)	24.0 9.6 (14.4)	25.7 18.7 (7.0)	21.4 13.7 (7.7)	23.4 13.9 (9.5)	19.8 12.7 (7.1)	29.6 18.7 (10.9)	23.9 18.0 (5.9)	**23.0** 14.3 8.7	12
TU-PURPLE	18.5 11.3 (7.2)	9.0 6.0 (3.0)	2.4 0.5 (1.9)	24.5 15.3 (9.2)	11.0 6.0 (5.0)	12.2 5.2 (7.0)	4.7 1.4 (3.3)	14.3 9.7 (4.6)	17.0 11.0 (6.0)	13.4 8.1 (5.3)	**13.0** 7.5 5.5	25
PG17265-N1	22.6 12.9 (9.7)	25.0 19.2 (5.8)	20.3 12.4 (7.9)	25.5 19.8 (5.7)	24.6 16.2 (8.4)	21.7 11.9 (9.8)	24.0 11.8 (11.2)	19.9 14.3 (5.6)	23.1 12.1 (11.0)	27.0 22.8 (4.2)	**23.4** 15.3 8.1	7
NWOYORIMA	13.8 9.6 (4.2)	15.5 9.7 (5.8)	12.6 4.3 (8.3)	22.2 16.7 (5.5)	12.0 8.0 (4.0)	13.5 9.1 (4.4)	22.3 16.6 (13.7)	14.7 7.5 (7.2)	24.0 13.5 (10.5)	18 0. 13.0 (5.0)	**17.0** 11.0 6.0	21
PO3/116	8. 0 5.4 (2.6)	13.0 8.1 (4.9)	27.1 22.8 (4.3)	22.5 14.6 (7.9)	10.0 4.0 (6.0)	12.2 7.2 (5.0)	23.8 15.3 (8.5)	18.5 9.4 (9.1)	13.9 8.8 (5.1)	21.0 13.3 (7.7)	**17.0** 11.0 6.0	21

TIS87/0087	21.3 11.2 (10.2)	15.0 7.8 (7.2)	14.4 9.5 (4.9)	19.0 11.3 (7.7)	20.5 11.5 (9.0)	14.2 9.2 (5.0)	23.6 17.7 (15.9)	19.7 13.6 (6.1)	25.6 17.8 (7.8)	22.5 13.0 (9.5)	**19.6** 12.3 7.3	1 7
LOCAL BEST	14.2 7.5 (6.7)	8.0 4.9 (3.1)	22.2 15.9 (6.3)	9.6 4.3 (5.3)	13.5 8.1 (5.4)	12.3 7.2 (5.1)	19.3 9.9 (9.4)	22.2 13.7 (8.5)	14.8 7.9 (6.9)	16.6 9.8 (6.8)	**15.3** 9.0 6.3	2 4
UMUSPO/ 3	13.1 6.7 (6.4)	18.2 12.9 (5.3)	13.5 8.6 (4.9)	21.0 17.6 (3.4)	22.6 14.6 (8.0)	19.7 11.1 (8.6)	10.0 5.5 (4.5)	24.6 19.7 (4.9)	22.4 17.8 (4.6)	24.3 15.7 (8.6)	**19.0** 13.0 6.0	1 8
Mean	**24.2** **17.7** **6.5**	**22.4** **16.5** **5.9**	**21.2** **15.1** **6.1**	**23.6** **17.0** **6.6**	**19.6** **12.7** **6.9**	**20.5** **13.9** **6.6**	**17.5** **10.7** **6.8**	**22.8** **15.0** **7.8**	**23.8** **17.6** **6.2**	**21.4** **15.5** **5.9**	22.0 15.0 6.5	
Range	8.0-- 41.4 5.4- 39.8 1.6- 12.7	8.0- 36.8 4.9- 28.2 3.1- 8.0	2.4 32.1 0.5- 26.9 1.9- 11.8	9.6 - 35.0 4.3- 27.4 2.7- 14.4	10.0 - 35.6 2.0-26.2 4.0-11.0	12.2- 38.8 4.0- 28.6 2.7- 11.0	1.5 –27.9 0.8-18.9 0.7-17.1	14.3 – 37.2 7.5 -26.4 2.9-13.6	13.9 – 34.5 8.8- 29.4 2.7- 14.4	12.0 – 32.0 4.2- 23.5 0.6- 8.6	13.0 – 34.1 7.5 - 26.5 5.0 – 8.7	
LSD (0.05)	5.0	4.8	4.7	4.9	4.5	4.6	4.5	4.8	4.9	4.7	4.8	
Sig. level	P<0.01 P<0.01 P<0.01	P<0. 01 P<0. 01 P<0. 01	P<0.0 1 P<0.0 1 P<0.0 5	P<0 .01 P<0 .01 P<0 .01	P<0.01 P<0.01 P<0.01	P<0.0 1 P<0.0 1 P<0.0 1	P<0.01 P<0.01 P<0.05	P<0.01 P<0.01 P<0.01	P<0.0 1 P<0.0 1 P<0.0 1	P<0. 01 P<0. 01 P<0. 01	P<. 01 P<0 .01 P<0 .05	
Location Rank	**1**	**5**	**7**	**3**	**9**	**8**	**10**	**4**	**2**	**6**	=	

***Figures in parenthesis are for small roots**

Total storage root weight: The combined analysis of the total storage root weight across locations indicated that the yield of the sweetpotato genotypes varied significantly (p<0.01) from 13.0.t/ha (Tu-purple) to 34.1t/ha (87/0p/195) with mean of 22.0t/ha. The genotype 87/OP/195, was ranked as a top yielder of total storage root yield and was ranked first in 8 out of 10 locations. This was followed by Cemsa 74-228 which came 2nd position with total storage root yield at first position in one out of 10 locations, while Tu-Purple was least with total storage root yield of 13.0t/ha and was ranked 25th as the poorest yielding genotypes. Based on yield selection differential, 12 genotypes with storage root yield potential above the general mean and with storage root yield more than the two Check varieties were selected for on-farm farmer' participatory varietal selection that will be conducted this year 2022. The following genotypes were selected for "On-farm farmers' participatory varietal selection: 87/OP/195 (34.1t/ha), Cemsa 74-228 (31.0t/ha), PGN16021-39 (26.6T/ha), PGA14011-43 (26.6t/ha), Cri-Okumkom (25.4t/ha), Cri-Apomuden (25.0t/ha), PGA14442-1 (24.2t/ha), PGN17362-N1 (24.0t/ha), PGA14398-4 (24.0t/ha). PGA17265-N1 (23.4t/ha), Cri-Dadanyuie (23.1t/ha) and PGA14351-4 (23.0t/ha). The on-farm evaluation is a stage where the farmers would be involved in the final varietal selection. The genotypes so selected by the farmers, if it were released by the varietal release committee will be adopted for cultivation by the farmers since it were selected by them. However, according to Nwankwo et al (2020) Sweetpotato genotypes with high yielding number of storage root potential per plant should be selected for further advancement and evaluation. Genotypes with large storage root number may be selected as having high storage root yield potential.

Commercial/large root weight: Storage root weighing 100g and above is regarded as large/commercial roots. The weight of the commercial roots differed significantly ($p<0.01$) among the various sweetpotato genotypes evaluated across the diverse agro-ecologies. Analysis across locations indicated that the weight of commercial roots ranged from 7.5t/ha (Tu-Purple) to as heavy as 26.5t/ha (87/OP/195) with grand mean of 22.0t/ha.

The location with the heaviest commercial root weight was Abia with mean weight of 17.7t/ha which ranged from 5.4 to 39.8t/ha. This was followed by Plateau location with mean commercial root weight of 17.0t/ha which ranged from 8.8t/ha to 29.4t/ha. The location with the least weight of commercial roots was Benue which had mean weight of 10.7t/ha and ranged from 0.8t/ha to 18.9t/ha. Commercial root weight is the storage root for commerce with heavy weight of fresh matter accumulation. Genotypes with heavy commercial root weight is an index of high photosynthetic efficiency and should be selected for on-farm farmers' participatory variety selection (Table 5). The major aim of breeding programmer is to breed and select varieties with commercial traits. Commercial trait in this context was to breed for large storage root yield with weights that generate income for the farmers. Varieties with large fresh storage weight root yield less than the check varieties should not be selected.

Non-commercial/Small root weight: This is a storage root with weight less than 100g. Non-commercial root weight varied significantly ($p<0.05$) across the locations with weight which ranged from 5.0 t/ha (PO3/116) to 8.7t/ha (PGA14351-4). However, the location with the heaviest non-commercial root was Kwara with mean weight of 7.8t/ha and which ranged from 2.9t/ha to 13.6t/ha followed by Akwa-Ibom with mean weight of 6.9t/ha which ranged from 4.0t/ha to 11.0t/ha. The location with the lowest weight was Osun with mean weight of 5.9t/ha and ranged from 3.1 to 8.0t/ha. Weight of non-commercial roots is an indication that fresh matter accumulation of the genotypes is very low in the high number of roots and that the genotype genetic constitution is not adaptable to the local environment. Genotypes with high weight of non-commercial root as a result of low photosynthetic efficiency will be discarded except if they are location specific in terms of storage root production. Nwankwo et al (2021) in their work on sweetpotato storage roots also reported that heavy weight of small roots is not a good index for selection. Heavy weight or high number of small storage roots is an indication of poor soil due to very low soil nutrient, poor genetic expression of the crop which may result due to poor agronomic management such as lack of weed control and climatic factors due to little or limited rainfall.

4.1: Vine weight at harvest: The mean vine weight (kg) of sweetpotato genotypes evaluated across ten diverse agro-ecologies of Nigeria is presented in Table 3.

Table 3: Mean Vine weight (kg) of sweetpotato genotypes evaluated across ten diverse agro-ecologies of Nigeria

Name of variety	Abia	Osun	Abuja	Nasarawa	Akwa-Ibom	Anambra	Benue	Kwara	Plateau	Kano	Mean	Rank
PGA14008-9	6.1	9.4	5.7	12.0	11.5	7.8	9.7	10.0	14.2	16.0	10.2	17
OBARE	8.8	12.2	10.9	9.5	6.5	5.0	7.0	12.0	9.4	10.0	9.1	24
KWARA	11.4	20.1	15.8	14.2	10.8	13.0	11.6	12.2	16.9	18.0	14.4	4
NAN	7.5	7.7	8.7	4.8	8.7	7.0	6.2	7.2	10.0	11.0	7.9	25
CRI-APOMUDEN	8.7	8.2	7.0	20.6	10.3	11.2	9.8	19.1	12.0	8.2	11.5	10
PG17362-NI	8.9	9.1	9.8	23.2	10.3	7.0	12.4	20.1	12.2	10.0	12.3	8
87/OP/195	9.4	9.2	9.1	11.9	11.2	9.9	9.6	16.0	7.2	8.2	10.2	17
PGN16021-39	10.5	8.2	7.8	10.3	9.4	10.6	7.3	13.2	19.1	8.0	10.4	15
CEMSA 74-228	6.2	10.7	6.3	12.1	10.5	9.5	9.3	16.4	15.1	11.3	11.0	12
PGA14442-110.2	6.7	12.3	6.7	10.6	6.7	10.7	9.5	11.9	16.0	10.8	10.2	17
BUTTER MILK	10.8	23.2	15.0	13.3	10.5	14.0	13.7	15.2	13.2	14.5	14.3	5
PGA14011-43	8.7	10.5	5.1	8.1	11.7	5.4	9.1	9.2	14.4	16.5	9.9	21
PGA14398-4	10.5	11.7	8.2	11.3	10.5	12.0	9.4	7.7	11.9	8.8	10.2	17
CRI-DADANYUIE	10.1	11.4	9.0	14.7	10.7	8.4	11.3	10.2	13.2	9.0	11.0	12
PGA14372-3	9.2	13.1	9.1	9.9	9.5	6.3	8.5	13.9	9.2	8.7	9.7	16
CRI-OKUMKOM	9.3	12.1	8.2	12.5	9.5	10.1	10.8	13.1	7.7	10.1	10.3	6
PO3/35	11.2	13.2	11.6	11.3	12.5	10.2	15.0	14.2	18.2	13.0	13.0	21
PGA14351-4	7.2	9.2	8.9	10.1	11.7	9.5	7.7	10.3	15.9	8.0	9.9	14

TU-PURPLE	12.7	8.9	7.3	13.5	10.0	12.0	11.1	11.3	13.1	8.0	10.8	11
PG17265-N1	13.0	9.6	8.0	10.5	11.2	9.8	13.6	10.2	15.0	10.0	11.1	3
NWOYO RIMA	12.0	22.6	22.1	17.4	15.6	13.2	17.6	9.9	12.5	12.0	15.5	7
PO3/116	15.0	16.8	9.3	14.1	10.1	12.6	9.0	7.8	17.2	12.0	12.4	2
TIS87/0087	15.6	18.3	12.6	22.2	19.4	13.8	14.3	21.5	22.0	20.0	18.0	1
LOCAL BEST	13.7	19.2	15.3	23.3	21.2	22.2	16.3	23.2	20.2	21.0	19.6	23
UMUSPO /3	8.9	11.3	8.3	12.6	9.0	8.9	8.7	12.1	9.4	9.0	9.8	9
MEAN	10.1	12.7	9.8	15.2	11.2	10.4	10.7	13.1	13.8	11.7	11.9	=
RANGE	6.1-15.6	7.7-23.2	5.7-22.1	4.8-23.2	6.5-21.2	5.0-22.2	7.0-17.6	7.2-23.2	7.2-22.0	8.0-21.0	7.9-21.0	
Rank	9	4	10	1	6	8	7	3	2	5		
LSD	3.2	3.6	3.1	3.9	3.4	3.2	3.3	3.3	3.1	3.4		
SIG.LEVEL	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	

Vine weight at harvest is the above ground biomass. It was observed from the result in Table 3 high significant (p<0.01) variation in vine weights among the genotypes within each location which resulted in variation in ranking. The mean vine weight (above ground biomass) of the sweetpotato genotypes across the locations ranged from 7.9 to 21.0t/ha The genotypes with the highest mean vine weight across location was TIS87/0087 with mean vine weight of 19.6t/ha and was given the first rank, followed by PO3/116 with 18.0t/ha and was given 2nd rank while the genotype with the least vine weight at harvest was NAN which had vine weight of 7.9t/ha and was given the last rank of 25th with grand mean of 11.9t/ha.

The vine weight of different genotypes showed large variation of above ground biomass at different environments/locations. The location with the highest vine weight was Nasarawa. The mean vine weights ranged from 4.8 to 23.2t/ha with grand mean vine weight of 15.2t/ha and was assigned the first rank. The second rank was assigned to Plateau location which had vine weights that ranged from 7, 2 to 22.0t/ha with grand mean of 13.8t/ha. The least vine weight was obtained from Abuja location. The vine weight ranged from 5.7 to 22.1t/ha with grand mean of 9.8t/ha.

Sweetpotato genotypes with heavy vine weight after harvest is of great importance in areas of livestock production. The above ground biomass is used as fodder for feeding cattle, sheep, goats, rabbits, pigs and even dried and included into poultry feed. However, the vine weight and total fresh weight of storage roots yield of the sweetpotato genotypes evaluated were used to calculate the harvest index.

5.1: Harvest index: The Harvest index of sweetpotato genotypes evaluated in ten diverse Agro-ecologies of Nigeria is presented in Table 3

Table 4: Mean total weights of Storage roots and Harvest index of sweetpotato genotypes evaluated in ten diverse Agro-ecologies of Nigeria

Names of variety	Mean storage root weight	Mean above ground biomass	Harvest index
PGA14008-9	22.0	10.2	0.7
OBARE	20.4	9.1	0.7
KWARA	19.0	14.4	0.6
NAN	21.0	7.9	0.7
CRI-APOMUDEN	25.0	11.5	0.7
PG17362-NI	24.0	12.3	0.7
87/OP/195	34.1	10.2	0.8
PGN16021-39	26.6	10.4	0.7
CEMSA 74-228	31.0	11.0	0.7
PGA14442-1	24.2	10.2	0.7
BUTTERMILK	15.5	14.3	0.5
PGA14011-43	26.6	9.9	0.7
PGA14398-4	24.0	10.2	0.7
CRI-DADANYUIE	23.1	11.0	0.7
PGA14372-3	21.6	9.7	0.7
CRI-OKUMKOM	25.4	10.3	0.7
PO3/35	18.0	13.0	0.6
PGA14351-4	23.0	9.9	0.7
TU-PURPLE	13.0	10.8	0.5
PG17265-N1	23.4	11.1	0.7
NWOYORIMA	17.0	15.5	0.5
PO3/116	17.0	12.4	0.6
TIS87/0087	19.6	18.0	0.5
LOCAL BEST	15.3	19.6	0.4
UMUSPO/3	19.0	9.8	0.7
Mean	22.0	11.9	0.6
Range	13.0 –34.1	7.9-21.0	0.4-0.8

Harvest index refers to the ratio of economic yield to biological yield of the crop. In this context, it is the storage root yield per unit area. Genotypes with high storage root yield have high harvest index. Harvest index could be used to select high storage root yielding varieties.

One of the limiting factors of Nigerian sweetpotato landraces are low yield in terms of number of storage roots per stand and fresh matter accumulation (storage root weight) per unit area (Degrass, 2000). The harvest index of the local best landrace was 0.4 while the genotype 87/OP/195 was 0.8. The harvest index could be used to select high yielding varieties among the genotypes evaluated. Significant (P<0.01) variation in the harvest index was observed among the genotypes tested and these ranged from 0.4 to 0.8 with mean of 0.6 (Table 8). High index genotypes accumulate large amount of fresh matter within short period of the growing season of four months. Based on this result, it indicated that 68% of the sweetpotato genotypes evaluated across the locations were high yielding per unit area with harvest index ranging from 0.7 to 0.8. The genotypes with harvest index above the grand mean 0.6 were selected for on -farm evaluation and for registration and release as high yielding storage root per unit area. (Table 3). Based on this, the following genotypes were selected:87/OP/105 (34.1t/ha), Cemsa 74-228 (31.0t/ha), PGN16021-39 (26.6t/ha), PGA14011-43 (26.6t/ha), Cri-Okumkom (25.4t.ha), Cri- Apomuden (25.0t/ha), PGA14442-1 (24.2t/ha), PGN17362-N1 (24.0t/ha), PGA14398-4 (24.0t/ha), PGA17265 (23.4t/ha), Cri-Dadanyuie (23.1t/ha) and PGA14351-4 (23.0t/ha).

CONCLUSION

Landraces have contributed much to the food menu of the people, economy of the country, and the farming system of the farmers. However, the good characteristics of the genotypes evaluated such as high storage root yield per unit area and adaptation to wide environments could be employed in breeding programme in the development of progenies that are adaptable to the biotic and abiotic stresses. The genotypes were selected as a result of their high harvest index and large storage root weight above their grand mean across the ten diverse agro-ecologies. The genotypes selected could be used as parents in the breeding programme to utilize their good qualities for progeny development and release for Nigerian farmers for domestic and industrial utilization. These genotypes should be tested On-farm for farmers to make their final selection.

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Effect of orange peels on growth responses of soybean, *Glycine max* in Igboora, Oyo State, Nigeria

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ABSTRACT

The pot experiment was conducted at the Teaching and Research farm of Oyo State College of Agriculture and Technology (OYSCATECH), Igboora to evaluate the growth response of Soybean (*Glycine max*). The experiment was laid out in Complete Randomized Design (CRD) with four treatments and replicated four times. The treatments were applied at the rate of 5 tonnes / ha, 10 tonnes / ha, 15 tonnes / ha and 20 tonnes / ha which were incorporated into the soil two weeks before sowing and wet daily for proper decomposition and rapid growth of bacteria, Rhizobia. Growth parameters taken were plant height (cm), number of leaves, leaf area (cm^2) and stem diameter (cm^2). Data collected were subjected to Analysis of Variance (ANOVA) and the means separated with Duncan Multiple Range Test (DMRT) at 5% probability level. Maximum growth was recorded with application of orange peels at the rate of 20 tonnes / ha. The above rate is therefore recommended for subsistence farming of soybeans.

KEYWORDS: Soybeans, Bacteria, Rhizobia, Orange peels.

INTRODUCTION

Glycine max is one of the most important crops cultivated around the world and it is the principal grain legume growth in the United States. Soybean is valued because it has high protein content which 38%. And the high protein content makes soybean important for both human and animal nutrition. Soybean are a valuable crop because they belong to the legume family and they also partner with a type of bacteria called Rhizobacteria. Soybean seeds inoculated with rhizobacteria before planting grow better than non-inoculated seeds. Orange peels have a high content of pectin. Because the peels are a by-product of orange juice production and they are in expensive.

The orange peel treatment could also increase the size of plants root, size and number of nodules(Pers.com) And this can have a positive influence in the amount of nitrogen that soybean can fix from the atmosphere thereby increasing plant growth and yield without the need of nitrogen fertilizers. The orange peel treatment helps to boost the activities of rhizome in soybean(Pers.com) Soybean is one of the most important crops cultivated around the world and it is the principal grain legume grown in the United States. It is valued because it has a high protein content – around 38%. And that high-protein content makes soybeans important for both human and animal nutrition. Besides having high protein content, soybeans are a valuable crop because they are in the legume family. The plants can pull nitrogen from the air into the soils and use it in the process of growing and producing the soybeans. But they don't do this alone, they do it through a partnership with particular bacteria.

Soybeans partner with a type of bacteria called rhizobacteria to turn airborne nitrogen into a usable nutrient for the plant. The roots of the soybeans have nodules, providing a home to rhizobacteria. The bacteria metabolizes nitrogen into a form the soybeans can use and in return the soybean plant provides that home, and some sugars that help the bacteria growth. Other types of rhizobacteria can help plants absorb some nutrients and others can protect the plant against pathogens that cause diseases.Past research showed that soybean seeds inoculated with rhizobacteria before planting grow better than non-inoculated seeds. Greenhouse studies have better results than field studies. This may be because the rhizobacteria are not able to survive very well in agricultural soils and gets outcompeted by the very numerous and diverse bacteria that are already present in that soil. The rhizobacteria need "food" to grow and colonize the soybean roots in order to stimulate plant growth. One type of food source for some strains of rhizobacteria is a carbohydrate called pectin. Pectin is found in fruits and vegetables, and you may recognize it as an ingredient in jams and jellies. Soybean is one of the most important crops cultivated around the world, and it is the principal grain legume grown in the United States. It is valued because it has a high-protein content about 38 percent. And that high-protein content makes soybeans important for both human and animal nutrition. The world population is growing fast and is expected to reach 9.7 billion people by 2050. To feed all those people, crop production needs to be increased worldwide. The most feasible way to do that is to increase yield, in other words, boost the quantity of grain produced by area cultivated. That also needs to be done in a sustainable way that allows for food production while protecting the environment.Besides having high-protein content, soybeans are a valuable crop because they are in the legume family. The plants can pull nitrogen from the air into the soils and use it in the process of growing and producing the soybeans. But they don't do that alone, they do it through a partnership with particular bacteria.Soybeans partner with a type of bacteria called rhizobacteria to turn airborne nitrogen into a usable nutrient for the plant. The roots of the soybeans have nodules, providing a home to rhizobacteria. The bacteria metabolizes nitrogen into a form the soybeans can use, and in return the soybean plant provides that home, and some sugars that help the bacteria growth. Other types of rhizobacteria can help plants absorb some nutrients and others can protect the plant against pathogens that cause diseases.

Objectives of the study

The objectives of this study are to determine the effect of orange peels on growth performance of soybeans and to determine the effect of orange peels on yield of soybeans.

MATERIALS AND METHOD

The experiment was conducted at the Teaching and Research Farm of Oyo State College of Agriculture and Technology Igboora. OYSCATECH is located along latitude 3018. 089E to 30 17.752'E and latitude 7024.875' N. Igboora is situated at 180m above sea level. The soil was collected on arable farm land of the research farm with the use of auger at 0-15cm depth which was air dried and sieve with 2mm sieve before weighing and filling into twenty 5kg pot. The composite sample was sent to the laboratory for evaluation of it's physico-chemical properties. The experiment was laid out in a Complete Randomized Design (CRD) with five (5) treatments replicated four (4) times. The orange peels were buried into the soil 2 weeks before sowing soybeans seeds and wet everyday. The treatments was applied at 50g, 100g, 150g and 200g and was replicated four times. Soybeans seed was sowed at 4 seeds per hole and thinned to one stand per pot at 2weeks after sowing. Weeds was uprooted by hand and wetting was carried out every morning. Yield parameters to be taken number of pods per plant by counting, weight of pods per plant by measuring scale (g), number of seeds per plant, weight of seeds per plant (g). Data collected was subjected to analysis of variance (ANOVA) and means separated with Duncan Multiple Range Test (DMRT) at 5% significant level.

RESULT AND DISCUSSION

Table 1: Physical and Chemical properties of soil

The chemical and physical properties of the soil used for the experiment shows a pH value of 5.70 (Table 1) indicating that the experimental soil was slightly acidic. The soil is low in essential plant nutrients like Nitrogen, Phosphorus and potassium with values of 1.12%, 7.25mg/kg and 0.27cmol/kg respectively.

Table 1: Physical and Chemical properties of soil

Soil properties	Value
pH	5.70
Total N	1.12%
Organic Carbon	1.30
Available Phosphorus	7.25 mg/kg
K	0.29 cmol/kg
Ca	5.22 cmol/kg
Mg	1.48 cmol/kg

Effect of Orange Peel on plant height of Soybean (*Glycine max*)

There was increase in plant height and development. There was no significant difference on P≤ 0.05 means at 1, 2, 3, 4, 5, 6 and 7 weeks after planting. However at 7 weeks after planting, orange peels (200g) has the highest number of plant height (83.62cm). While the control has the lowest number of plant height (46.55cm).

Table 2: Effect of Orange Peels on plant height of Soybean

Treatment	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP
CONTROL	13.12a	22.95a	26.60a	33.27a	35.00a	38.88a	46.55a
OP1	12.62a	23.52a	29.68a	48.30a	50.50a	54.20a	61.25a
OP2	9.28a	24.00a	31.37a	41.12a	40.00a	44.57a	61.17a
OP3	9.25a	26.90a	28.53a	51.25a	52.75a	57.12a	97.00a
OP4	11.88a	36.48a	51.17a	70.05a	71.75a	75.88a	83.62a

Means with the same letter are not significantly different number of leaves P ≤ 0.05 means WAP – Weeks after planting.

Effect of Orange Peel on number of leaves of Soybean (*Glycine max*)

There was increase in number of leaves at 1, 2, 3, 4, 5, 6 and 7 weeks after planting. There was no significant differences on P≤0.05 means in number of leaves among the treatment at 1, 2 and 3 weeks after planting. However, there was significant difference among the treatment P≤0.05 means at 4, 5, 6, and 7 weeks after planting. At 7 weeks after planting, orange peels (200g) has the highest number of leaves (51.25). While the control has the lowest number of number of leaves (22.00cm).

Table 3: Effect of Orange Peels on number of leaves of Soybean (*Glycine max*)

Treatment	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP
CONTROL	8.25a	10.75a	12.50a	14.50b	16.75b	20.00c	22.00b
OP1	7.50a	10.00a	14.50a	19.50ab	21.00b	27.25bc	29.50b
OP2	8.25a	11.00a	14.00a	17.25b	21.62b	28.25bc	30.50b
OP3	6.00a	11.25a	14.75a	21.00ab	45.00a	51.25a	36.00ab
OP4	5.50a	15.00a	15.00a	26.00a	36.75a	45.00a	51.25a

Means with the same letter are not significantly different number of leaves P ≤ 0.05 means WAP – Weeks after planting. OP1: orange peels at the rate of 50g, OP2: orange peels at the rate of 100g, OP3: orange peels at the rate of 150g, OP4: orange peels at the rate of 200g, CONTROL: No application

Effect of Orange Peels on leaf area of Soybean (*Glycine max*)

There was increase in the leaf area of soyabean plant at 1, 2, 3, 4, 5, 6 and 7 weeks after planting. There was no significant difference on P≤0.05 means at 1, 2, and 3 WAP However there was significant difference on P≤0.05 means at 4, 5, 6 and 7 weeks after planting. At 7 weeks after planting, orange peels (200g) has the highest number of leaf area (119.80cm^2), while the control has the lowest leaf area (61.9cm).

Table 4: Effect of Orange Peels on leaf area of Soybean (*Glycine max*)

Treatment	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP
CONTROL	21.32a	27.38a	36.75a	42.02b	50.38b	56.94c	61.95b
OP1	24.38a	35.45a	52.80a	71.73a	76.15a	86.12b	99.50a
OP2	34.97a	47.43	47.67a	67.45a	75.20a	83.53b	108.15a
OP3	32.78a	49.95a	53.67a	68.69a	81.40a	104.30ab	116.33a
OP4	31.32a	59.70a	75.88a	85.97a	91.03a	116.08a	119.80a

Means with the same letter are not significantly different number of leaves P ≤ 0.05 means WAP – Weeks after planting. OP1: orange peels at the rate of 50g, OP2: orange peels at the rate of 100g, OP3: orange peels at the rate of 150g, OP4: orange peels at the rate of 200g, CONTROL: No application

Effect of Orange Peels on stem diameter of Soybean (*Glycine max*)

There was increase in the stem diameter at 1, 2, 3, 4, 5, 6 and 7 weeks after planting. There was no significant difference on p≤0.05 means at 6 and 7 weeks after planting. However, there was significant difference on P≤0.05 means at 1, 2, 3, 4 and 5 weeks after planting. At 7 weeks after planting , the orange peels (50g) as the highest number of stem diameter (2.05cm).

Table 5: Effect of Orange Peels on Stem Diameter (cm) of Orange Peels

Treatment	1WAP	2WAP	3WAP	4WAP	5WAP	6WAP	7WAP
CONTROL	1.02b	1.12b	1.20b	1.25b	1.32b	1.45a	1.55a
OP1	1.15a	1.25a	1.35a	1.48a	1.73a	1.92a	2.05a
OP2	1.20a	1.30a	1.40a	1.50a	1.57ab	1.67a	1.77a
OP3	1.15a	1.25a	1.35a	1.42a	1.48ab	1.65a	1.77a
OP4	1.23a	1.32a	1.38a	1.50a	1.65a	1.80a	1.72a

Means with the same letter are not significantly different number of leaves P ≤ 0.05 means WAP – Weeks after planting. OP1: orange peels at the rate of 50g, OP2: orange peels at the rate of 100g, OP3: orange peels at the rate of 150g, OP4: orange peels at the rate of 200g, CONTROL: No application

CONCLUSION AND RECOMMENDATION

In the results presented above, it was evident that the growth parameters of soybeans performed best with the use of orange peels in plant height, number of leaves, stem diameter and leaf area to enhance the growth of soybean. This is may be due to the high nutrient contents in 200g than the other treatments. *Glycine max* is one of the most important crops cultivated around the world and it is the principal grain legume growth in the United States. Soybean is valued because it has high protein content which 38%. And the high protein content makes soybean important for both human and animal nutrition. Soybean are a valuable crop because they belong to the legume family and they also partner with a type of bacteria called Rhizobacteria In the results presented above, it was evident that the growth parameters of soybeans performed best with the use of orange peels in plant height, number of leaves, stem diameter and leaf area to enhance the growth of soybean. In the results presented above, it was evident that the growth parameters of soybeans performed best with the use of orange peels in plant height, number of leaves, stem diameter and leaf area to enhance the growth of soybean. 200g of orange peel as proved to have the best results and thereby recommended to soybeans farmers in the study area.

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Farming System Studies on Rainfed Maize (Zea Mays) at Three Levels of Nitrogen in Unwuna, Southeastern Nigeria

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ABSTRACT

A farming system study to investigate the effect of three nitrogen levels on maize production under rainfed condition was carried out at the experimental farm of the Department of Horticulture and Landscape Technology, AkanuIbiam Federal Polytechnic, Unwana during the 2021 farming season. **A** Randomized Complete Block Design (RCBD) with four blocks. *Mucuna (Mucuna utilis)* plant was planted five months to the maize planting at a spacing of 45cm x 60cm. This was allowed to flower and then ploughed into the fields before maize planting.The maize seeds were sown at a spacing of 25cm x 75cm. Three levels of nitogen (100, 130 and 160kg N ha^{1}) from ammonium sulphate were randomly applied to the experimental units in split doses, one- third at planting (broadcasted), two- third at tasselling (By side dressing), while blanket application of single superphosphate and muriate of potash by broadcasting at planting at the rates of 50kg P_2O_5 ha^{1} and 40kg K_20 ha^{1} was done.The growth and yield parameters collected were days to 50% tasseling, days to 50% silking, plant height, mean number of leaves, number of cobs harvested per row, field weight of fresh cobs and dry grain weight per plant. Also, nutrient composition of the harvested grains including N, P, K, Ca, Mg, Cu and Na were determined in the laboratory. All data were subjected to analysis of variance (ANOVA) and means separated using $LSD_{0.05.}$ Results showed variabilties in both growth and yield attributes,but none was statistically significant. However,yield of maize increased with nitrogen levels. Inclusion of mucuna in the cropping system improved soil fertility condition and yield of maize.

Keywords: Farming system, Rainfed, Maize and Nitrogen

INTRODUCTION

Farming system has been holistically defined as a complex interrelated matrix of soil, plant, animal, implements, power, labour, capital and other inputs by farming families and influenced to varying degrees by political, economic, institutional and social forces that operate at many levels (Dixon *etal*., 2001). Proper farming system ensures efficient resource use that translates into maximum crop yield.

Maize is the world's third most important cereal after wheat and rice. It is grown primarily for grain and secondarily for fodder and raw material for industrial processes. Maize production in the recent years has declined drastically due poor soil conditions in southeastern Nigeria.(Ahalawart *et al.*, 1981) Therefore, to enhance maize productivity in the face of declining soil fertility, external fertilizer input is necessary.Inclusion of legumes into cropping systems has been traditionally used to improve soil fertility especially nitrogen nutrition (Brady and Weil, 2008). Legumes through their association with rhizobia bacteria promote nitrogen fixation which profits not only the immediate crop, but the successive crops (Azu *et al.*, 2020).

The introduction of mineral fertilizers especially nitrogen fertilizer into cropping system to improve soil fertility and crop nitrogen nutrition is a radical intervention that has over the years led to increased crop yield (Azu*et al.*, 2018). However, the use of mineral nitrogen fertilizer in recent times has not yielded the expected gain in terms of crop yield due to variable soil conditions, climate change, and improper use of nitrogen fertilizers in terms of quantity and application method.Also, poor organic matter content of most tropical soils predisposes these soils to leaching of soil nutrients especially mobile elements like nitrogen.

Thus, proper understanding of a sound farming system that integrates legumes and nitrogen fertilizer at optimum quantity and varying time of application in relation to rainfall pattern of a given region is very much fundamental to crop yield maximization. This information is still lacking in the hydromorphic soils of Unwana, southeastern Nigeria. This forms the basis of this paper.

MATERIALS AND METHODS

This study was carried out in the Research Fram of Department of Horticulture and Landscape Technology, AkanuIbiam Federal Polytechnic Unwana, (coordinates: latitude $5^{0}48$'N and longitude $7^{0}55$'E). The air temperature is generally high all year round and the current temperature range is 32^{o}C -21^{o}C with total annual rainfall exceeding 3,500 mm (Njoku, 2006). The soil of the experimental area is a TypicHapludult(Federal Department of Agriculture and Land Resources, 1985). The land area was earlier used for cassava cultivationThe maize variety used was a composite Downy Mildew, Resistant (DMR), Early maturing (E), Streak Resistance (SR), Yellow (Y), (DMRESR-Y) from the International Institute of Tropical Agriculture (IITA), Ibadan. Velvet bean (Mucunautillis) collected from IITA was used as green manure, while the fertilizers used were ammonium sulphate for nitrogen, single superphosphate and muriate of potash as sources of phosphorus and potassium respectively.

A Randomized Complete Block Design (RCBD) with four blocks was used for the study. The experiment covered a total land area of 0.366ha. Each block consisted of three plots measured 16m x 18.3min area with 21 plant rows in each plot and spacing of 75cm between rows, 1.0m between plots and 2.0m between blocks. The mucuna was planted five months prior maize planting at a spacing of 45cm x 60cm. This was allowed to flower before being ploughed in and harrowed, ready for maize planting.Two maize seeds were sown per hole at a spacing of 25cm x 75cm and thinned down two weeks after germination. There were 72 plants per row, giving a theoritical population of 53,333 plants per hectare. Three levels of nitogen (100, 130 and 160kg N ha^1) from ammonium sulphate were randomly applied to the experimental units in split doses, one- third at planting (broadcasted), two- third at tasselling (By side dressing). Blanket application of single superphosphate and muriate of potash by broadcasting at planting at the rates of 50kg P_2O_5 ha^1 and 40kg K_20 ha^1 was done. Weeding, pest control and other agronomic practice were observed throughout the growth period.

The growth and yield parameters collected were days to 50% tasseling, days to 50% silking, plant height, mean number of leaves, number of cobs harvested per row, field weight of fresh cobs and dry grain weight per plant. Also, nutrient composition of the harvested grains including N, P, K, Ca, Mg, Cu and Na were determined in the Laboratory according to standard methods. Simlarly, pre-planting and post-harvest soil samples picked randomly from the site were also analyzed for nutrient compositions according to standard methods. Data obtained from plant and soil parameters were subjected to statistical analysis using analysis of variance (ANOVA) and means separated using $Lsd_{0.05}$ as outlined by Steel and Torie (1980).

RESULTS AND DISCUSSION

Pre-planting and post-harvest soil chemical analysis of the experimental site showed that the soil was acidic, high in nitrogen and other nutrient elements(Table 1). However, the organic matter content were low in both the pre-planting and post-harvest soil samples. This indicates the potential for leaching of even the cations (Brady and Weil, 2008). The observed increase in organic matter after harvest may be attributed to more leaf fall due to moringa intercropping system.

The mean effect of different levels of nitrogen on Days to 50% tasseling,Days to 50% silking, plant height, plant ear height and number of leaves is presented in table 2. Results showed that there were differences on these properties due to levels of nitrogen application. However, these differences were not statistically significant. This result is contrary to the reports of Fox *et al*., (1974) who reported significant different on growth parameters of maize due the applation of different levels of nitrogen.

Table 1. Pre-planting and Post-harvest Chemical properties of the soil from the experimental site

Properties	Before planting	After harvest
pH in 1:2.5 soil/water	4.72	5.07
pH in 1:2.5 soil/KCL	4.06	4.23
Total N (g/kg)	33.00	24.00
Available P (mg/kg)	8.90	7.20
Exchangeable Ca (cmol/kg)	189.60	206.60
Exchangeable K (cmol/kg)	58.00	52.60
Exchangeable Mg (cmol/kg)	44.00	34.80
Copper Cu (cmol/kg)	Trace	Trace
Iron, Fe (cmol/kg)	20.80	20.10
Zinc, Zn (cmol/kg)	1.27	1.27
Organic matter (%)	1.89	2.18

Table 2 Mean effects of nitrogen levels on growth of maize

Parameters	Nitrogen Levels (KgN/ha) 100	130	160
Days to 50% Tasselling	66.50	66.25	66.25
Days to 50% Silking	71.50	69.25	70.50
Plant Height (cm)	121.25	115.0	123.99
Plant ear Height (cm)	46.04	43.83	49.46
Number of leaves	8.94	8.49	3.37

The mean effects of different levels of nitrogen on yield attributes of maize, including number of cobs per row, field freshweight,dehusked oven-dried weight per cob, oven-dried grain weight per cob and maize yield is shown in table 3. The yield parameters increased with rate of nitrogn application. Howver,these increaseas were not statistically significant. Nitrogen has been reported by several scholars as an essential element necessary for incrased plant growth and yield (Brady and Weil, 2008).

Table 3 Mean effects of nitrogen levels on yield of maize

Parameters	Nitrogen Levels (KgN/ha) 100	130	160	Significance
Number of cobs per row	25.38	27.28	27.32	Not
Field weigth of per plant (g)	217.77	199.37	225.71	Not
Dehusked oven-dry weight per cob(g)	153.05	161.66	152.76	Not
Oven-dry grain weight per cob (g)	55.59	59.03	54.54	Not
Maize grain yield (kg/ha)	2733.49	2888.44	2881.50	Not

The nutrient composition of the harvested maize from plots of different levels of nitrogen application is shown in table 4. The effect of different levels of nitrogen on the ntrient composition of maize was not significant. However, the were variability on the concentration of different nutrients contianed in the maize grains as a result of nitrogen application at different levels. Apart from potassium which showed clear increase in amount due to increase in nitrogen level, the variability in other nutrients compositions of maize due to levels of nitrogen application did not follow particular trend (Eneje and Azu, 2009). However, the incorpoation of the mucuna and addition of nitrogen generally increased the nutrient composition of the maize grain. Onwuka *et al.*, (2007) has previously reported inceased nutrient composotion of maize grain as a result of addition of organic manure and mineral fertilizers in the cropping system.

Table 4. Mean effects of nitrogen levels on nutrient composition of maize grain

Parameters	Nitrogen Levels (KgN/ha) 100	130	160	Significance
Nitrogen (%)	10.03	9.10	9.48	Not
Phosphorus (mg/kg)	6.03	6.08	6.25	Not
Potassium (cmol/kg)	148.13	165.08	157.23	Not
Magnesium (cmol/kg)	40.53	40.18	41.41	Not
Calcium (cmol/kg)	0.48	0.54	0.46	Not
Copper(cmol/kg)	0.19	0.13	0.15	sigificant
Sodium(cmol/kg)	2.48	1.53	2.05	Not

CONCLUSION

The inclusion of mucuna and different levels of nitrogen fertilizer in the farming system improved the soil fertility properties, growth, yield and nutrient compositions of maize grain. Incorporation of mucuna and 160kgN/ha gave the most appreciabe improvement of soil fertility indices, growth and yield of maize and the nutrient composition of maize and therefore recommeded for acid soils of Unwana, southeastern Nigeria.

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Antimicrobial activity of selected plant extracts on fungal pathogens of watermelon (*Citrullus lanatus)* fruits and leaves

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PROCEEDINGS
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ABSTRACT
Diseases constitute a major challenge to watermelon production in Nigeria through fruit yield and quality reduction. The diseases render the fruits unmarketable and inedible. Hence, this study identified the fungal pathogens associated with the leaves and fruits of watermelon using molecular characterization. The study also evaluated the potential antimicrobial activities of ethanol extracts of three selected plants: (leaves of *Vernonia- amygdalina*, *Piliostigma-reticulatum and Spondias- mombin*) against the fungal species.
The statistical analysis of the study was done using analysis of variance (ANOVA) and means were compared by using Duncan's Multiple Range test (DMRT).
The results showed that all the plants materials have antifungal potentials on the fungal species with *P. reticulatum* extracts having the highest antifungal activity (100%) at 50mg/ml, 100mg/ml and 200mg/ml. The diameters of inhibition zone varied according to leaf extract and concentration *Vernonia- amygdalina* and *Spondias- mombin* also showed significant zone of inhibition (100%) at 100mg/ml and 200mg/ml.
The study concluded that the plant extracts used have varying anti-fungal reactions on the three fungal pathogens detected and as such can be used as natural antibiotic and antimicrobial agents against plant diseases.

Keywords: plant extracts, fungal, antimicrobial, zone of inhibition.

INTRODUCTION
Watermelon (*Citrullus lanatus)* belongs to the family Cucurbitaceae (Koocheki *et al*., 2007) is a tropical fruit that grows in most parts of Africa and South East Asia. Besides its high nutritional value, it is gaining a high level of economic importance in income generation. Watermelon flesh is an excellent source of vitamins, minerals and anti-oxidants that help in preventing human diseases by acting as oxygen radical scavenger (Reetu et al., 2017). The

sweetness of watermelon is due to the presence of sucrose, glucose and fructose. Sucrose and glucose account for 20-40% and fructose for 30-50% of total sugars in a ripe watermelon (Bianchi et al., 2018).
Diseases such as blossom-end rot, bursting and rind necrosis reduce the yield and quality of watermelon fruit thereby making it unmarketable and inedible which in turn causes loss to the farmers (Donald et al., 2015).

The use of plants extracts is gaining momentum in the last few years in managing plant diseases. Many plants have been used because of their antibiotic and antimicrobial traits, which are due to compounds synthesized during secondary metabolism in the plants. These natural plant products are cheap, readily available, has little or no toxicity to humans (eco-friendly) and are easy to prepare.
Therefore, the objectives of this study are to:

- identify some fungal pathogens associated with *C. lanatus* leaves and fruits.
- assess the efficacy of three plant extracts in the management of these fungal pathogens.

MATERIALS AND METHODS

Collection of plants materials

Fresh leaves of *Vernonia- amygdalina, Piliostigma- reticulatum and Spondias- mombin* were collected from Ago Iwoye, Ijebu North Local Government Area, Ogun State in Nigeria. The leaves were collected in polyethylene bags and transported to the Postgraduate Plant Science Laboratory of the Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun State.

Botanical identification

Botanical identifications were carried out at the Elikaf Herbarium, Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

Collection of infected fruits and leaves of *C. lanatus.*

Eighteen infected fruit samples and forty-two infected leaf samples were collected from eleven field in Ijebu North Local Government Area of Ogun State. They were packed into sterilized transparent bags, labeled and transported to Post Graduate Plant Science Laboratory of the Department of Plant Science Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria.

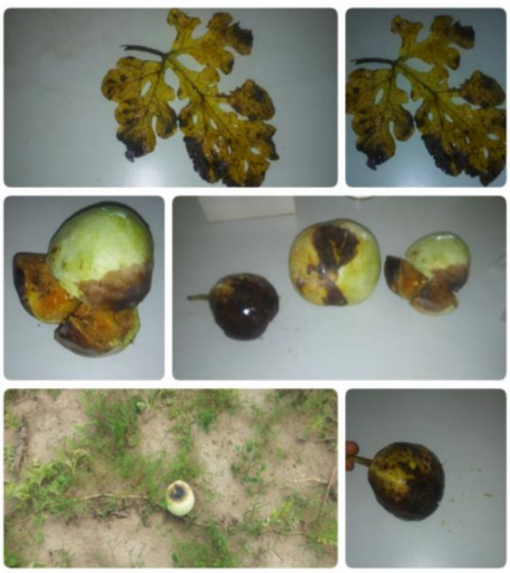

Figure 1: Infected watermelon fruits and leaf samples

Preparation of Culture Media

Potato dextrose agar (PDA) was used as the medium for the growth and maintenance of the fungi isolates.Nineteen and half gram (19.5g) of PDA powder was weighed and dispensed into 500millilitres of distilled water in a conical flask. The mixture was stirred vigorously to dissolve. The conical flask was covered with a foil paper and sealed with a masking tape. The content was sterilized in an autoclave at 121°c for 15 minutes and allowed to cool at room temperature.

The medium was poured into sterile Petri-dishes and allowed to solidify before inoculation was performed.

Isolation of Pathogens from Infected leaves and fruits of *C. lanatus*.

The infected fruits and leaf samples of *C. lanatus* were rinsed in sterile distilled water and small pieces of the rotten parts were picked using a sterile scalpel and placed directly on sterile PDA. The plates were incubated for 3 days at room temperature and sub-culturing was done to obtain pure cultures of the isolate. After incubation, different growths of mycelia colony were sub-cultured with the aid of sterilized inoculating loop into newly prepared PDA plates. The plates were incubated at room temperature for 3-5 days. Several sub-culturing was done, thus purifying the mixed culture plates. The purified fungi were transferred into McCartney bottles of broth agar and stored for characterization.

Identification of Fungi Isolates

The fungal strains were identified using molecular sequencing analysis. The genes (DNA extraction) of the fungal isolates were sequenced with universal primer of (ITS4TCCTCCGCTTATTGACATGS and ITS5GGAACTAAAAGTCGTAACAAGG) and the results are *Fusarium equiseti, Lasiodiplodia theobromae* and*Choanephora cucurbitarum.*

Preparation of Plants Materials

Five hundred grams each of mature fresh leaves of *V. amygdalina*, *P. reticulatum* and *S. mombin* were thoroughly rinsed in running tap water and air dried at room temperature. The samples were oven dried at a temperature of 55˚C for 30 minutes before grinding into powder with pestle and mortar to facilitate extraction. The samples were ground separately. The leaves were macerated (soaked) in an air-tight plastic container containing 1000ml of 99.9/100% ethanol at room temperature and was stirred using a sterile aluminum rod of 50cm length for 5days to allow for maximum extraction of the plants components and to encourage homogeneity of the plants extract and the solvent used. This was followed by filtration with what-man filter paper and the filtrate was concentrated using steam-water bath. The residue was put into sample bottles as the crude extracts of the test plants and stored.

Concentrations of Crude Extracts

Serial dilutions of the crude extracts were prepared using 0.2g in 1ml of 99.9/100% ethanol and concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml were prepared.

Preparation of Biological Assay

Potato dextrose agar was prepared according to manufacturers' instruction and allowed to cool. The different concentrations of the extracts (25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml) were dispensed into the Petri dishes. The prepared PDA was dispensed into the extracts of the different concentrations, the plates were gently mixed to dissolve the contents using agar dilution method. Four-millimeter diameter of mycelia incubated from old culture of each test fungi was inoculated centrally into the medium using cock borer(4mm) and was incubated for 48 hours to 120hours. The inhibition rate of the plant extracts was observed and measured. The control consists of Petri plates with the organisms but with no plant extract. The inhibition rate was recorded starting from day 2 to day 5. The rate of mycelia growth inhibition (MGI) was calculated using the formula (Jeum *et al*., 2015):

GI% = dc-dt/dc×100

where dc is mean colony diameter of control sets and dt is mean colony diameter of treatment sets.

Statistical Analysis

Test for significance in the zone of inhibition was done using analysis of variance (ANOVA) and means were compared using Duncan's Multiple Range test (DMRT).

RESULTS

Antifungal effects of the plants extracts on *F. equiseti* at different concentrations

Table 1 shows the percentage inhibition of the plant extracts concentration. On *Fusarium equiseti*, *S. mombin* extracts had percentage mycelia inhibition of 52.80%, 70.30%, 100% and 100% for concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml respectively while the control was 0.00%. For *P. reticulatum*, the percentage mycelia inhibition was 70.53%, 100%, 100% and 100%, while *V. amygdalina* showed the percentage mycelia inhibition of 35.70%, 100%, 100% and 100% respectively.

Ethanol extracts of *P. reticulatum* and *V. amygdalina* at 50mg/ml, 100mg/m and 200mg/ml completely inhibited the growth of *F. equiseti* (100%) while *S. mombin* showed complete inhibition at 100mg/m and 200mg/ml on *F. equiseti.* Thus, the test plants extracts showed no significant difference ($P \geq 0.05$) on *F. equiseti* at 100mg/ml and 200mg/ml while at 25mg/ml and 50mg/ml showed significant difference ($P \leq 0.05$).

Analysis of variance on percentage of *F. equiseti* of the three plants extracts showed significant difference ($P \leq 0.05$) between plant extracts and concentrations of the extracts on *F. equiseti.* The table also shows that the inhibitory effects of the test plants increased with concentrations of the extracts. In comparison, the inhibitory effect of *P. reticulatum* extracts is higher than other extracts at all concentrations.

Table 1: Duncan's Multiple Range Test of Percentage Inhibition (%) at Different concentrations on *Fusarium equiseti*

Table 1.1: Effects of *Spondias mombin* on *Fusarium equiseti*

	Fusarium equiseti	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	Control	3	.0000			
	25 mg/ml	3		58.8000		
	50 mg/ml	3			70.3000	
	100 mg/ml	3				100.0000
	200 mg/ml	3				100.0000
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 1.2: Effects of *Pilostigma reticulatum* on *Fusarium equiseti*

	Fusarium equiseti	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		

	25 mg/ml	3		70.5333	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 1.3: Effects of *Vernonia amgydalina* on *Fusarium equiseti*

	Fusarium equiseti	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		35.7000	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Antifungal effects of plants extracts on *L. theobromae* at different concentrations

Table 2 shows the percentage inhibition of the plant extracts. The percentage inhibition of the plant extracts was concentration dependent on *Lasiodiplodia theobromae*. *S. mombin* extracts had percentage mycelia inhibition of 23.72%, 84.21%, 100% and 100% for concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml respectively while the control was 0.00%. For *P. reticulatum*, the percentage mycelia inhibition was 54.27%, 100%, 100% and 100%, while *V. amygdalina* showed percentage mycelia inhibition of 23.63%, 44.67%, 74.83% and 100%.

Ethanol extracts of *P. reticulatum* and *S. mombin* at 100mg/m and 200mg/ml completely inhibited the growth of *L. theobromae* (100%) while *V. amygdalina* showed complete inhibition at 200mg/ml on *L. theobromae.* Thus, the test plants extracts showed no significant difference ($P \geq 0.05$) on *L. theobromae* at 100mg/ml and 200mg/ml of *P. reticulatum* and *S. mombin* while at 25mg/ml and 50mg/ml showed significant difference ($P \leq 0.05$) on the extracts.

The inhibitory effects of the test plants increased with concentrations of the extracts. In comparison, the inhibitory effect of *P. reticulatum* extracts is higher than other extracts at all concentrations. Analysis of variance showed significant difference ($P \leq 0.05$) between plant extracts and concentrations of the extracts on *L. theobromae.*

Table 2: Duncan's Multiple Range Test of Percentage Inhibition (%) at Different concentrations on *L. theobromae*

Table 2.1: Effects of *Spondias mombin* on *Lasiodiplodia theobromae*

	Lasiodiplodia theobromae	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	Control	3	.0000			
	25 mg/ml	3		23.7667		
	50 mg/ml	3			84.2067	
	100 mg/ml	3				100.0000
	200 mg/ml	3				100.0000
	Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 2.2: Effects of *Pilostigma reticulatum* on *Lasiodiplodia theobromae*

	Lasiodiplodia theobromae		Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		54.2667	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 2.3: Effects of *Vernonia amgydalina* on *Lasiodiplodia theobromae*

	Lasiodiplodia theobromae	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan[a]	Control	3	.0000				
	25 mg/ml	3		23.6333			
	50 mg/ml	3			44.6667		
	100 mg/ml	3				74.8333	
	200 mg/ml	3					100.0000
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Antifungal effects of plants extracts on *C. cucurbitarum* at different concentrations

The percentage inhibition of the plant extracts was concentration dependent on *Chaonephora cucurbitarum*. *S. mombin* extracts had percentage mycelia inhibition of 22.40%, 32.73%, 42.53% and 100% for concentrations of 25mg/ml, 50mg/ml, 100mg/ml and 200mg/ml respectively while the control was 0.00%. For *P. reticulatum*, the percentage mycelia inhibition

was 83.70%, 100%, 100% and 100%, while on *V. amygdalina* showed the percentage mycelia inhibition of 21.33%, 27.10%, 58.83% and 89.46% (Table 3).
Ethanol extracts of *P. reticulatum* and *S. mombin* at 200mg/ml showed a complete inhibition on *C. cucurbitarum* (100%), while *V. amygdalina* showed no complete inhibition at all the concentrations on *C. cucurbitarum*. Thus, the test plants extracts showed no significant difference ($P \geq 0.05$) on *C. cucurbitarum* at 200mg/ml of *P. reticulatum* and *S. mombin* while at 25mg/ml, 50mg/ml and on *V. amygdalina* showed significant difference ($P \leq 0.05$) on the plant extracts.
The inhibitory effects of the test plants increased with concentrations of the extracts. In comparison, the inhibitory effect of *P. reticulatum* extracts is higher than other extracts at all concentrations. Analysis of variance showed significant difference ($P \leq 0.05$) between plant extracts and concentrations of the extracts on *C. cucurbitarum* (Table 3).

Table 3: Duncan's Multiple Range Test of Percentage Inhibition (%) at Different concentrations on *C. cucurbitarum*

Table 3.1: Effects of *Spondias mombin* on *Choanephora cucurbitarum*

	Choanephora cucurbitarum	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan[a]	Control	3	.0000				
	25 mg/ml	3		22.4000			
	50 mg/ml	3			32.7333		
	100 mg/ml	3				42.5333	
	200 mg/ml	3					100.0000
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 3.2: Effects of *Pilostigma reticulatum* on *Choanephora cucurbitarum*

	Choanephora cucurbitarum	N	Subset for alpha = 0.05		
			1	2	3
Duncan[a]	Control	3	.0000		
	25 mg/ml	3		83.7000	
	50 mg/ml	3			100.0000
	100 mg/ml	3			100.0000
	200 mg/ml	3			100.0000
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Table 3.3: Effects of *Vernonia amgydalina* on *Choanephora cucurbitarum*

	Choanephora cucurbitarum	N	Subset for alpha = 0.05				
			1	2	3	4	5
Duncan[a]	Control	3	.0000				
	25 mg/ml	3		21.3333			

	50 mg/ml	3			27.1000		
	100 mg/ml	3				58.8333	
	200 mg/ml	3					89.4667
	Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

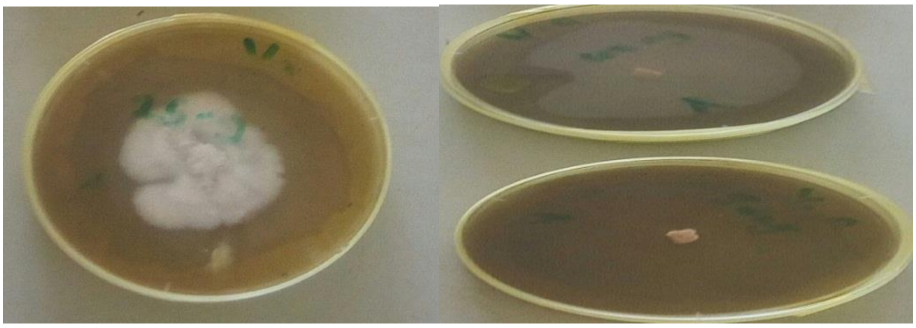

Plate A: *F.equiseti* with *V.amygdalina* at 25mg/ml

Plate B:*F.equiseti* with *V.amygdalina* at 100mg/ml and 200mg/ml

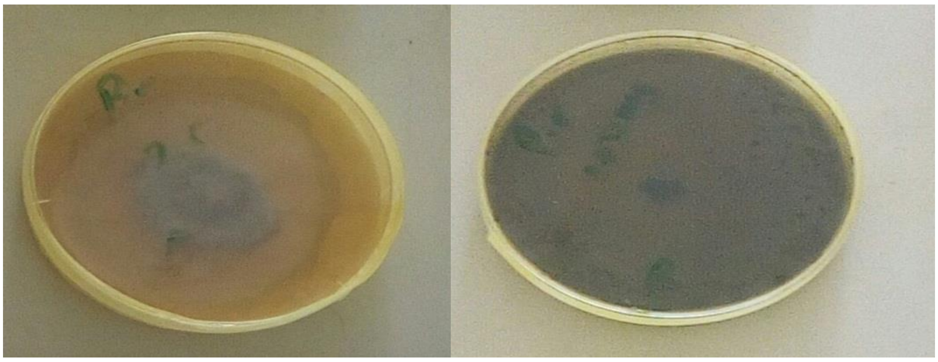

Plate C:*C.cucurbitarum* with *P.reticulatum* at 25mg/ml

Plate D:*C.cucurbitarum* with *P.reticulatum* at 100mg/ml

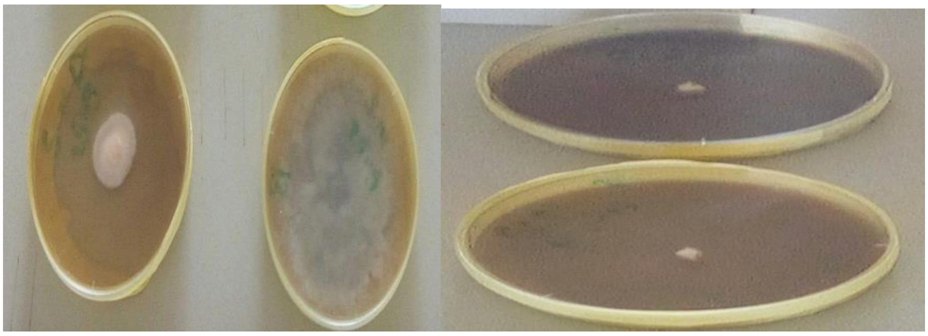

Plate E: *F. equiseti* and *L. theobromae* with *S. mombin* at 25mg/ml

Plate F*: F. equiseti* with *S. mombin* at 100mg/ml and 200mg/ml

Figure 2: Mycelia growth inhibition of fungi with *V. amygdalina, P. reticulatum* and *S. mombin*

DISCUSSION

This study shows three different fungal isolates associated with infected fruits and leaves of watermelon distributed among the seven locations within Ijebu North Local Government Area, Ogun State. *Lasiodiplodia theobromae* appeared in more locations than other fungal isolates on infected fruits and *Fusarium equiseti* appeared in more locations than other fungal isolates on infected leaves of watermelon.

The antifungal effects of *V. amygdalina, P. reticulatum and S. mombin* leaves extracts against; *F. equiseti, L. theobromae and C. cucurbitarum* at different concentrations obtained in this study drastically reduced the mycelia growth of the three fungi strains over a period of 4-5days at (96-120hours) of incubation.

This study revealed the fungal pathogens affecting *C. lanatus* in Ijebu North Local Government Area of Ogun State. In a similar study, Garba *et al*., (2014) reported isolation and identification of bacteria and fungi associated with rots of *Citrullus lanatus* and *Capsicum frutescens* in Sokoto market in Nigeria. List the pathogens detected in Sokoto market. Ratul *et al*. (2010) reported molecular detection and identification of *Fusarium oxysporum* as the fungal species as identified in this study.

Vernonia- amygdalina have been reported to have antifungal activities against some fungal pathogens (Bazie *et al*., 2014; Aondo *et al*., 2016). Stangarlin *et al*. (2011) reported that control of plant diseases using some plant extracts and at different concentrations of *P. reticulatum* on the fungal strains showed a great result of inhibition against the tested pathogen and this could be attributed to the antibiotic properties of the plant. It is therefore a botanical with potential antifungal property (Aderogba *et al.*, 2006). The plant contains very active biological agents that could be used to control fungal diseases of plants.

According to Ngoci *et al*., (2015), *P. reticulatum* extracts show significant antimicrobial activities against some fungi. *Pilostigma reticulatum* had higher antifungal potential compared to other plant extracts used which justified the report of Akomolafe *et al.* (2013), which showed that ethanol and aqueous extracts of *P. reticulatum* have been widely used as herb and also as antibiotic owning to several bioactive constituents it contains. The findings showed that ethanol and aqueous extracts of this plant had strong antioxidant properties.

Garuba *et al.* (2014) reported the ethanolic extracts of *V. amygdalina* showed antifungal potential against *Aspergillus. niger, A. clavatus, A. oryzae, Paecilomyces varioti and Saccharomyces cerevisae*. It was also reported that water extract of *V. amygdalina* leaves have inhibition effect on the growth of *Fusarium moniliforme* and mycelial and conidial growth of *Collectotrichum gloeosporioides* (Owolade *et al.*, 2000; Ogbebor *et al*., 2007; Suleiman *et al.*, 2008). Nkaa *et al*. (2016) also reported that leaf extract of *S. mombin* reduced the radial mycelial growth of *Proteus- mirabilis* and *Staphylococcus aureus*. Report also showed that ethanol leaf extract of *S. mombin* plant has antifungal activities against some fungal pathogens (Osuntokun *et al.*, 2018) as observed in this study.

CONCLUSION

Findings from this study, showed that the plant extracts used have varying anti-fungal activities on the three fungal pathogens detected.

The observed inhibition zone of *F. equiseti*, *L. theobromae* and *C. cucurbitarum* suggests that *P. reticulatum* possesses compounds containing antifungal properties that can effectively suppress the growth when extracted with ethanol. Therefore, *P. reticulatum* leaves exhibit the potential of being a good natural antibiotic agent against plant diseases caused by *F. equiseti, L. theobromae and C. cucurbitarum.*

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Bacteriological Assessment of Banana Vended in Benin City Edo State, Nigeria.

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ABSTRACT

The microbiological content of Banana (a fruit), commonly vended in the Benin metropolis of Edo state were evaluated. Five vending locations were chosen for the study. Whole and soft rot samples were purchased and analysed for microbiological composition. Results showed high counts in soft rot samples in banana. Nutrient Agar plated banana samples had bacterial counts in the range of 1.0×10^2 to 6.3×10^5. *Pseudomonas* species was the dominant species found in banana samples. Mac Conkey agar plated banana samples ranged from 0.0×10^2 to 7.2×10^5. *Enterobacter* species, *E. coli*, and *Klebsiella* species were the dominant species isolated. The study observes that soft rot samples are usually cheaper in the market and have higher microbial counts which when consumed could pose a risk of introducing pathogens to the consumer which could be detrimental to the health of the consumer.

Enter Keywords: Bacteriological, Fruit, Microbiological, Banana, and vendor

INTRODUCTION

Generally, the trend in the world today is towards healthy eating more than ever. People are more conscious of what they eat, associating same with health conditions presently or in later years of life (Oriakpono *et al*., 2011; Odu and Akano, 2012). Fresh fruits are commonly found vended on the streets and in shops under both hygienic and unhygienic conditions. While many are less concerned with the processing and hygiene of these fruits for consumption, they pose a direct risk of causing microbial food borne illness particularly when highly contaminated with microorganisms. Fruits help to strengthen the immune system, fight disease, and boost the overall body health. Fruits are loaded with most of the essential antioxidants (Vitamins A, C, E and Lycopene) which the body may not produce on its own. Antioxidant nutrients help the body prevent disease, fight illness, and stave off the signs of aging. Fruits are an important source of nourishment, providing a ready source for the metabolism of some vital vitamins and nutrients required in healthy and balanced diets. Well balanced diets, rich in fruits and vegetables, are especially valuable for their ability to prevent vitamin C and vitamin A deficiencies and are also reported to reduce the risk of several diseases (Kalia and Gupta, 2006). Fruits products are usually exposed to potential microbial contaminants during the periods of cultivation, harvesting, transporting, packaging, storage and sale to the final consumers who may be purchasing on the streets, fruit shops or local market (Oranusi and Olorunfemi, 2011; Ibeyessie, 2007; Lelieveld *et al*.,2003). Apart from the great beneficial aspects of fresh fruits, they may serve as a source of food poisoning when contaminated with pathogenic microorganism during harvesting, human handling, transport containers and display in street markets or when in contact with fecal materials (Artes *et al*., 2007). Enteric pathogens such as *Escherichia coli* and *Salmonella* are among the greatest concerns during food-related outbreaks (Helen *et al*., 2018; Buck *et al*., 2003). Organic fertilizer or contaminated irrigated water may bring about contamination of fruits and vegetables. The lack of effective antimicrobial treatments at any step from planting to consumption means that pathogens introduced at any point may be present on the final food product even when available antimicrobials are applied, they may bring about a change in the final product. Such changes may include a change in the taste, colour, or the quality of the product (Patricia *et al*., 2002). Fresh vegetables and fruits may be washed or treated specifically to minimize microbial load (FDA, 2000). Food safety is of growing concern for consumer and professionals in the food industry worldwide (Schuele and Snead, 2001). Food safety in ready to eat produce especially raw foods live fruits and vegetables has long been an object of study with many assessing the microbiological condition of raw fresh fruits and vegetables available in street markets as well as in self-service and fast food restaurants (Angela *et al*., 2010). Consumers need to recognize the importance of food safety particularly for fresh fruits and vegetables which are commonly consumed. The objectives of this study therefore were to evaluate the bacteriologic assessment of fresh banana from street vended locations in Benin City Edo State and to identify the bacteria genus present on locally obtained banana.

MATERIALS AND METHODS

One hundred (100) banana fruit samples (50 whole and 50 soft rot banana) were purchased from 5 different vending locations in Benin metropolis in Edo State, Nigeria. The fruit from each sampling location were transported to the laboratory in a cool box at $\pm\ 4^0$C.

Preparation of Samples for Microbiological Analysis

Ten grams (10g) of banana were cut from each sample using a sterile scapel. These were separately added to 90ml of 0.1% peptone water and homogenized separately in a blender. One millilitre of each homogenate was transferred to separate test tubes containing 9ml peptone water to obtain a dilution of 10^{-1}. In a similar manner, 1ml each was transferred from this dilution to separate test tubes containing 9ml diluents and the process was repeated until a dilution of 10^{-9} was obtained for the banana samples (ISO 4832: 2006).

Enumeration of Microorganisms

0.1ml from each dilution of samples was transferred to plates of nutrient agar using the spread plate technique. Plates containing nutrient agar were incubated at 37^0C for 18-24hrs. Counts were made after incubation from plates having 30-300 colonies.

Identification of Bacterial Isolates

Bacterial colonies with characteristic edges, colours and sizes were isolated and purified by subculturing on nutrient agar plates and examined with a hand lens. Each isolate was subjected to biochemical test using the Bergey's Manual of Systematic Bacteriology. The different tests carried out were used in identifying the isolates to their genus level.

RESULTS

Microbiological analyses of the banana samples carried out on both whole and soft rot samples revealed some variation in bacterial count and diversity. For the nutrient agar plates, *Pseudomonas* species was the predominant organism in both whole and soft rot samples in locations 1 to 5. It was observed that whole samples had lower bacterial counts than soft rot samples.

No organism was isolated from the whole banana samples obtained from the five (5) locations. The soft rot samples showed varying microbial counts in samples from the different locations. *Klebsiella* species was the predominant organism isolated from soft rot banana samples obtained from the five (5) locations. *Enterobacter* species and *Escherichia coli* were isolated from samples from location 2 only. *Escherichia coli* and *Klebsiella* species were the predominant organisms isolated from whole samples in the five locations. Soft rot samples from the five (5) locations revealed the presence of *Escherichia coli, Klebsiella* species and *Enterobacter species*. *Proteus* species was isolated from soft rot samples from location 5 only.

Morphological characteristics of the test organisms revealed that the diameter of the colonies were in the range of 0.2- 3.0mm.

Table 1: Morphological Characteristics of the Isolate

Sample code	Organism	Colony Characteristics
BL1.	*Pseudomonas* species	Greenish colonies of 0.4mm in diameter, circular, raised, opaque, with entire edges.
B 2.	*Escherichia coli*	Pink, convex, opaque, smooth surface, entire edge, circular, 1-2mm in diameter
B 3.	*Klebsiella* species	Pink, convex, opaque, smooth surface, circular, entire edge, 1-2mm in diameter
B 4.	*Enterobacter* species	Colourless, flat, serrated edge circular, 1-2mm in diameter.

Key: B – Banana

Table 2: Results for Nutrient Agar plated Banana samples from Location 1

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWN1-01	2.0×10^2	*Pseudomonas* species	BSN1-01	6.2×10^5	*Pseudomonas* species
BWN2-01	1.3×10^2	*Pseudomonas* species	BSN2-01	4.5×10^5	*Pseudomonas* species
BWN3-01	1.0×10^2	*Pseudomonas* species	BSN3-01	3.8×10^5	*Pseudomonas* species
BWN4-01	1.9×10^2	*Pseudomonas* species	BSN4-01	5.5×10^5	*Pseudomonas* species
BWN5-01	$1.5 \text{ X } 10^2$	*Pseudomonas* species	BSN5-01	6.0×10^5	*Pseudomonas* species
BWN6-01	2.1×10^2	*Pseudomonas* species	BSN6-01	5.7×10^5	*Pseudomonas* species

Table 3: Results for Nutrient Agar plated Banana samples from Location 2

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWN1-02	2.3×10^2	*Pseudomonas* species	BSN1-02	4.5×10^5	*Pseudomonas* species

BWN2-02	2.2×10^2	*Pseudomonas* species	BSN2-02	6.3×10^5	*Pseudomonas* species
BWN3-02	1.9×10^2	*Pseudomonas* species	BSN3-02	4.9×10^5	*Pseudomonas* species
BWN4-02	1.7×10^2	Pseudomonas species	BSN4-02	5.7×10^5	*Pseudomonas* species
BWN5-02	1.5×10^2	*Pseudomonas* species	BSN5-02	3.1×10^5	*Pseudomonas* species
BWN6-02	2.4×10^2	*Pseudomonas* species	BSN6-02	4.7×10^5	*Pseudomonas* species

Table 4: Results for Nutrient Agar plated Banana samples from Location 3

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWN1-03	1.2×10^2	*Pseudomonas* species	BSN1-03	5.2×10^5	*Pseudomonas* species
BWN2-03	2.9×10^2	*Pseudomonas* species	BSN2-03	5.3×10^5	*Pseudomonas* species
BWN3-03	2.6×10^2	*Pseudomonas* species	BSN3-03	5.5×10^5	*Pseudomonas* species
BWN4-03	2.5×10^2	*Pseudomonas* species	BSN4-03	5.5×10^5	*Pseudomonas* species
BWN5-03	2.4×10^2	*Pseudomonas* species	BSN5-03	5.4×10^5	*Pseudomonas* species
BWN6-03	2.1×10^2	*Pseudomonas* species	BSN6-03	5.2×10^5	*Pseudomonas* species

Table 5: Results for Nutrient Agar plated Banana samples from Location 4

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWN1-04	3.3×10^2	*Pseudomonas* species	BSN1-04	4.3×10^5	*Pseudomonas* species
BWN2-04	1.2×10^2	*Pseudomonas* species	BSN2-04	4.2×10^5	*Pseudomonas* species
BWN3-04	2.5×10^2	*Pseudomonas* species	BSN3-04	4.7×10^5	*Pseudomonas* species
BWN4-04	1.3×10^2	*Pseudomonas* species	BSN4-04	5.9×10^5	*Pseudomonas* species
BWN5-04	2.1×10^2	*Pseudomonas* species	BSN5-04	5.7×10^5	*Pseudomonas* species
BWN6-04	3.1×10^2	*Pseudomonas* species	BSN6-04	4.6×10^5	*Pseudomonas* species

Table 6: Results for Nutrient Agar plated Banana samples from Location 5

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWN1-05	1.3×10^2	*Pseudomonas* species	BSN1-05	4.2×10^5	*Pseudomonas* species
BWN2-05	1.6×10^2	*Pseudomonas* species	BSN2-05	5.5×10^5	*Pseudomonas* species
BWN3-05	1.3×10^2	*Pseudomonas* species	BSN3-05	4.4×10^5	*Pseudomonas* species
BWN4-05	1.9×10^2	*Pseudomonas* species	BSN4-05	3.9×10^5	*Pseudomonas* species

BWN5-05	1.7 x 10^2	*Pseudomonas* species	BSN5-05	6.1 x 10^5	*Pseudomonas* species
BWN6-05	1.3 x 10^2	*Pseudomonas* species	BSN6-05	5.3 x 10^5	*Pseudomonas* species

Table 7: Results for Mac Conkey Agar plated Banana samples from Location 1

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWM1-01	0.0 x 10^2	No organism	BSM1-01	3.2 x 10^4	*Klebsiella* species
BWM2-01	0.0x 10^2	No organism	BSM2-01	2.1 x 10^4	*Klebsiella* species
BWM3-01	0.0 x 10^2	No organism	BSM3-01	3.5 x 10^4	*Klebsiella* species
BWM4-01	0.0x 10^2	No organism	BSM4-01	3.4 x 10^4	*Klebsiella* species
BWM5-01	0.0x 10^2	No organism	BSM5-01	4.2 x 10^4	*Klebsiella* species
BWM6-01	0.0x 10^2	No organism	BSM6-01	3.1 x 10^4	*Klebsiella* species

Table 8: Results for Mac Conkey Agar plated Banana samples from Location 2

Sample code	Whole sample	Organism found	Sample code	Soft rot samples	Organism found
BWM1-02	0.0 x 10^2	No organism	BSM1-02	6.1 x 10^5	*Klebsiella* species, *Enterobacter* species, *E. Coli*
BWM2-02	0.0x 10^2	No organism	BSM2-02	7.2 x 10^5	*Klebsiella* species, *Enterobacter* species, *E. Coli*
BWM3-02	0.0x 10^2	No organism	BSM3-02	6.5 x 10^5	*Klebsiella* species, *Enterobacter* species, *E. Coli*
BWM4-02	0.0x 10^2	No organism	BSM4-02	7.2 x 10^5	*Klebsiella* species, *Enterobacter* species, *E. Coli*
BWM5-02	0.0x 10^2	No organism	BSM5-02	4.9 x 10^5	*Klebsiella* species, *Enterobacter* species, *E. Coli*
BWM6-02	0.0x 10^2	No organism	BSM6-02	4.7 x 10^5	*Klebsiella* species, *Enterobacter* species, *E. Coli*

Table 9: Results for Mac Conkey Agar plated Banana samples from Location 3

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWM1-03	0.0 x 10^2	No organism	BSM1-03	5.2 x 10^4	*Klebsiella* species
BWM2-03	0.0x 10^2	No organism	BSM2-03	4.3 x 10^4	*Klebsiella* species
BWM3-03	0.0x 10^2	No organism	BSM3-03	5.2 x 10^4	*Klebsiella* species
BWM4-03	0.0x 10^2	No organism	BSM4-03	6.1 x 10^4	*Klebsiella* species
BWM5-03	0.0x 10^2	No organism	BSM5-03	3.2 x 10^4	*Klebsiella* species
BWM6-03	0.0x 10^2	No organism	BSM6-03	4.3x 10^4	*Klebsiella* species

Table 10: Results for Mac Conkey Agar plated Banana samples from Location 4

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWM1-04	0.0 x 10^2	No organism	BSM1-04	3.4 x 10^4	*Klebsiella* species
BWM2-04	0.0x 10^2	No organism	BSM2-04	5.1 x 10^4	*Klebsiella* species
BWM3-04	0.0x 10^2	No organism	BSM3-04	3.2 x 10^4	*Klebsiella* species
BWM4-04	0.0x 10^2	No organism	BSM4-04	4.2 x 10^4	*Klebsiella* species
BWM5-04	0.0x 10^2	No organism	BSM5-04	4.5 x 10^4	*Klebsiella* species
BWM6-04	0.0x 10^2	No organism	BSM6-04	5.4 x 10^4	*Klebsiella* species

Table 11: Results for Mac Conkey Agar plated Banana samples from Location 5

Sample code	Whole samples	Organism found	Sample code	Soft rot samples	Organism found
BWM1-05	0.0 x 10^2	No organism	BSM1-05	3.2 x 10^4	*Klebsiella* species
BWM2-05	0.0x 10^2	No organism	BSM2-05	2.4 x 10^4	*Klebsiella* species
BWM3-05	0.0x 10^2	No organism	BSM3-05	4.3 x 10^4	*Klebsiella* species
BWM4-05	0.0x 10^2	No organism	BSM4-05	4.7 x 10^4	*Klebsiella* species
BWM5-05	0.0x 10^2	No organism	BSM5-05	3.4 x 10^4	*Klebsiella* species
BWM6-05	0.0x 10^2	No organism	BSM6-05	3.6 x 10^4	*Klebsiella* species

Table 12: Percentage of Microorganisms found

Microorganisms	Percentage (%)
***Pseudomonas* spp**	43
***Enterobacter* spp**	7
***Klebsiella* spp**	43
Escherichia coli	7

KEY:
BWN 1-6 Banana Whole Samples Plated On Nutrient Agar
BSN 1-6 Banana Soft Rot Samples Plated On Nutrient Agar
BWM 1-6 Banana Whole Samples Plated On Macconkey Agar
BSM 1-6 Banana Whole Samples Plated On Macconkey Agar
01 – 05 Location from which Samples were purchase

Table 13: Biochemical characterization of bacterial isolates from the banana samples

Isolate code	Grams reaction	Cell morphology	Oxidase	Catalase	Citrate	Starch hydrolyses	Spore test	H_2S	MR	VP	Indole	Sucrose	Lactose	Motility	Maltose	Mannitol	Probable genera
	-	Rods	+	+	+	-	-	-	-	-	+	A/G	A/G	+	A	-	*Pseudomonas* species
	-	Rods	-	+	-	-	-	-	+	-	+	A/G	-	+	-	A	*Escherichia coli*
	-	Rods	-	+	+	-	-	-	-	+	-	A	-	-	A	A	*Klebsiella* species
	-	Rods	-	+	+	-	+	-	+	+	-	A	A	+	-	A	*Enterobacter* species

Note: +,Positive, -,Negative, A,acid production, G, gas production.

DISCUSSION

Fruits play a vital role to strengthen the immune system by providing some required essential antioxidants which may be difficult for the body to synthesize on its own. This study evaluated the quality of some fruits sold in Benin metropolis based on their bacteriological contents, which were tagged locations 1,2,3,4 and 5. This study observed that high microbial contaminants were found in sampled banana particularly in the soft rot samples obtained from the five market locations in Benin City. The microbial content of the soft rot sample is alarming and calls for concern because after consumption they may become pathogenic causing ailment in the consumer of such products. Microorganisms most commonly found in fruits are *Pseudomonas* species (Jay, 2003). Result from this study are comparable with those of Riordan *et al.* (2001), who reported that consumption of soft rot banana fruits is commonly viewed as a potential risk factor for infections with enteropathogens such as *Escherichia coli.*

Pseudomonas species is known to be an opportunistic pathogen of clinical relevance demonstrating a great deal of metabolic diversity, thus their ability to colonize a wide range of niches. *Pseudomonas* species have been found to be endosymbionts and operate a synergistic interaction to enhance plant growth. In this study, the *Pseudomonas* species were found in the tissues of banana fruit. *Klebsiella* species is also considered an opportunistic pathogen that produce significant endotoxin that can mediate fatal infection. The presence of *Escherichia coli* in banana calls for proper care and hygienic practice (Jay, 2003; Baiyewu *et al*., 2007). This is because travelers are known to patronize vendors and subsequently find themselves with the challenges of consuming fruits that may be contaminated with bacteria that may predispose them to health issues such as diarrhea or gastroenteritis.

CONCLUSION

The bacteriological assessment of fruits ready for public consumption shows contamination by various organism (*Pseudomonas*, *Enterobacter*, *Klebsiella* species and E. coli), which poses a risk for the consumer. This contamination problem can be caused by various factors such as environmental problems (pollution of water resources) and the use of animal fertilizers for treatments. Therefore, this research calls for hygienic practices in handling these vended products and strongly dissuades consumers from purchasing fresh fruits with signs of soft rot as their microbiological quality have been compromised, though in the market the price of fruits in their early state of soft rot are usually cheaper than whole samples. Consumers who purchase these cheap products face a risk of ingesting microbial pathogens that may be highly detrimental to their health. It is therefore recommended that optimal conditions of hygiene; transportation and storage should be observed, so that the product gets to the consumer at the best quality and safe from microbial induced spoilage. Also consumers are advice not to purchase fresh fruits and vegetables with signs of soft rot as their microbiological quality have been compromised. Lastly, there should be awareness on the health implication of pathogens introduced during cross contamination.

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Genetic Variability and Correlation Studies of Some Mineral Composition and other Agronomic Traits of Maize (*Zea mays* L) in Keffi, Nasarawa State, Nigeria.

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ABSTRACT

This study was conducted to assess the genetic variability, correlation of some mineral composition and other agronomic traits of 14 maize genotypes. The field study was conducted during the 2017 cropping season at the Department of Plant Science and Biotechnology Research Garden, Nasarawa State University, Keffi. These maize genotypes were evaluated in Randomized Complete Block Design (RCBD) with three (3) replicates. The results obtained from the analysis of variance for the agronomic traits studied showed significance differences ($p < 0.005$) for leaf length, leaf width, leaf area, boron and zinc. The significant differences observed among the genotypes indicated the presence of genetic variability among them. The total variation of phenotypic coefficients of variations (PCV) showed that the PCV were higher than the genotypic coefficients of variations (GCV) for all the traits measured except for molybdenum and zinc which GCV was higher than PCV, indicating the influence of environment in the expression of these characters. Heritability estimates were recorded for plant height, number of leaves, leaf length, leaf width, leaf area, ears per plant, anthesis-silking interval, days to maturity, boron, and zinc, moderate broad sense heritability was recorded for grain yield, and molybdenum. The genetic gain as a percentage mean in this study was high for leaf width, leaf area, EPP and ASI, indicating that these traits were under the control of additive genes. Genetic advance expressed as percentage of mean was observed for ear length, and number of kernels per row. Low estimates of genetic advances expressed as percentage of mean, were observed on plant height, leaf length, days to maturity, grain yield, boron and zinc indicating the presence of low genetic variability for these traits which are also reflected in their respective low genotypic and phenotypic variations. Positive correlation was observed between ears per plant and grain yield. This shows the importance of genetic variability for the improvement of the studied traits through selection.

Key words: Genetic variability, mineral composition, maize, Nasarawa State.

INTRODUCTION

Maize (Zea mays L, 2n=2x=20), a member of the grass family Gramineae (Poaceae), is one of the oldest cultivated crops. Maize generally called corn (Hausa name-Masara) is an annual cross-pollinating plant with the female (silk) and male (tassel) flowers bound on two separate positions (Abate *et al.*, 2015). Maize otherwise kwon as corn is one of the most widely grown and commonly cultivated all over the world (Abate *et al.*, 2015).

Maize is a preferred staple food for about 900 million poor consumers and about one third of all malnourished children (Laurence & Peters, 2012). Maize is used in many ways than any other cereal. It is considered as a multi-purpose crop and has been put to a wider range of uses such as human food, animal and poultry feed and for hundreds of industrial purposes. (Yusuf, 2010). It is palatable and nutritious, higher in fats (4%) than rice and wheat and also contains about 10% protein (Iqbal *et al*., 2015). Maize can be cooked in a variety of ways to make very palatable and popular foods. Every part of the plant has economic value. (Taya, 2014). The grain, leaves, stalks, and even the cob, are used to produce hundreds of food and nonfood products (Nzuve *et al.*, 2014).

Information on the nature and magnitude of variability and heritability in a population is one of the prerequisites for successful breeding program in selecting genotypes with desirable characters. Genetic improvement in traits of economic importance along with maintaining sufficient amount of variability is always the desired objective in maize breeding programs. In order to improve the genetic diversity of local germplasm, it is important to know the extent of already existing genetic variations in the material.

In Nigeria, maize improvement started half a century ago (Mosisa *et al.*, 2002). During the late 1960s and early 1970s, several promising genotypes of east African origin were introduced and evaluated at different locations. Different studies were conducted to elucidate the nature and magnitude of genetic variability among maize inbred lines which identified traits like ear length, ear diameter, kernel number per row, ears per plant, 100 seed weight and rows per ear as potential selection criteria in a breeding program.

MATERIALS AND METHODS

Study area

The research was carried out in the Department of Plant Science and Biotechnology Research Garden of the Nasarawa State University Keffi, which lies between Latitude 8.847^{o}N and longitude 7.905^{o}E about 68KMfrom Abuja, the federal capital (Awka *et al*., 2007).

Experimental materials

The experimental materials consist of fourteen (14) lines obtained from local farmer. The maze lines used for this research include, H1, H2, L1, L2, L3, Y1, Y2, Y3, Y4, Y5, W2, W3, W4, and W5.

Experimental design/field layout

The genotypes obtained were planted in a randomized complete block design (RCBD) with three replications. The plot size was 2m x 2m with plant spacing of 75 cm by 25 cm. Observations on the agronomic traits were recorded on 5 individual plants, randomly selected from each plot.

Data collection

Ears per plant, anthesis-silking interval (ASI), plant height (cm), leaf length (cm), days to pollen, days to silking, days to maturity, number of cubs per plant and grain yield (t/ha)

Statistical analysis

Data collected were all subjected to analysis of variance using General Linear Model procedure of Statistical Analysis System (SAS) package (SAS, 2002). Principal Component Analysis (PCA) using the correlation matrix to test the different mineral elements in each of the samples.

RESULTS AND DISCUSSIONS

The result on Table 1, indicated highly significant differences ($P \leq 0.05$) for leaf length, leaf width, leaf area, boron and zinc. The significant differences observed among the genotypes indicated the presence of genetic variability in them, while the non-significant ones indicate that they may be conditioned by the same genes and are genetically related for these characters. It might be possible that the genotypes are related through some remote ancestors. These results indicated that there is significant genetic variability for the traits, thus genetic improvement can be achieved for these traits (leaf length, leaf width and leaf area). Hence, suitable hybrids could be developed. This is in agreement with the findings of Showemimo *et al.* (2000a & 2000b) and Aghaei *et al*. (2012) who reported performance or expression of genes controlling maize characters to be strongly influenced by environmental variation.

The mean performance of fourteen maize genotypes evaluated for yield and other agronomic traits is presented in table2, Indicated a wide range of variability for traits such as number of rows per ear, kernels per row, kernels per ear, ear length, ear diameter, 100-kernels weight and plant height. Yoseph (2005) also reported that grain yield, plant height, ear height and days to maturity showed wide range of variation, while number of leaves, leaf width and ear diameter showed a narrower range of phenotypic variation of maize in Ethiopia. In general, range and mean values in this study suggested the existence of sufficient variability among the tested genotypes for the majority of the traits studied and their considerable potential in the improvement of maize crop.

Table 1: Mean Squares from ANOVA of Fourteen Maize Genotypes for Agronomic Traits and yield Evaluated at Keffi 2018

Source of variation	Df	PH	NL	LL	LW	LA	EPP	ASI	DM	GY	Mo	B	Zn
Rep	2	596.95	1.45	145.17	1.02	0.01	0.45	0.21	1.81	3242.78	0.02	0.00	0.61
Gen	13	627.83	1.1	309.98**	2.42**	0.03**	0.20	0.24	7.88	3473.85	0.01	0.02**	2.04**
Error	26	304.88	0.79	71.24	0.79	0.01	0.25	0.42	6.48	3674.34	0.02	0.00	0.08

** = significant at 0.05 probability levels. PH= Plant Height (cm), NL= Number of Leaves, LL=Leaf Length (cm), LW=Leaf width (kg), LA= Leaf Area (cm^2), EPP= Ears Per Plant, ASI= Anthesis-Silking Interval, DM= Days to Maturity, GY=Grain Yield (kg/ha), Mo= Molybdenum, B=Boron and Zn= Zinc

Table 2: Mean Performance of 14 Maize Genotypes Evaluated for Agronomic Traits and Yield in Keffi 2018

Gen	PH	NL	LL	LW	LA	EPP	ASI	DM	GY	Mo	B	Zn
H2	123.33	12.33	86.67	8.67	2.57	1.67	2.00	84.67	92.99	0.01	0.53	1.39

H1	122.67	11.67	75.33	8.00	2.47	1.33	2.67	84.33	106.67	0.01	0.54	1.34
L2	132.33	12.67	109.33	10.00	2.74	2.00	2.33	86.00	161.37	0.02	0.55	1.42
L1	110.00	11.67	79.67	8.00	2.50	1.67	2.33	84.67	207.86	0.02	0.54	1.73
L3	110.33	12.33	88.33	10.00	2.64	1.67	2.67	88.67	153.16	0.01	0.53	1.47
Y5	93.00	10.67	67.00	7.33	2.41	1.67	2.33	85.00	82.05	0.01	0.46	1.63
Y1	100.33	11.67	80.00	8.67	2.54	1.67	2.33	86.00	114.87	0.01	0.42	3.84
W2	114.00	11.67	87.67	7.67	2.52	2.00	3.00	86.67	114.87	0.05	0.43	0.74
Y4	89.00	12.00	73.67	7.67	2.44	1.33	2.33	87.67	123.08	0.20	0.44	1.05
W4	108.67	12.67	78.33	9.67	2.58	1.67	2.67	88.67	153.16	0.18	0.43	1.29
W5	115.67	11.67	79.33	8.33	2.51	1.67	2.33	85.33	95.73	0.25	0.34	1.17
W3	97.67	11.00	72.33	8.33	2.39	1.67	2.33	84.00	136.75	0.10	0.36	0.90
Y3	138.33	12.67	88.00	9.67	2.63	1.00	3.00	86.00	98.46	0.05	0.35	0.67
Y2	101.33	12.00	84.00	8.33	2.54	1.67	2.67	83.67	112.14	0.05	0.40	0.25
Mean	111.20	11.90	82.12	8.60	2.34	1.62	2.50	85.81	125.20	0.07	0.45	1.35
CV (%)	15.20	7.45	10.28	10.36	3.79	30.71	25.90	2.97	48.41	167.00	4.82	20.65
LSD(P < 0.05)	29.31	1.49	14.17	1.50	0.16	0.84	1.09	4.27	101.70	0.19	0.04	0.47

PH= Plant Height (cm), NL= Number of Leaves, LL=Leaf Length (cm), LW=Leaf width (kg), LA= Leaf Area (cm^2), EPP= Ears Per Plant, ASI= AnthesisSilking Interval, DM= Days to Maturity, GY=Grain Yield (kg/ha), Mo= Molybdenum, B=Boron and Zn= Zinc

The estimates of coefficient of variation for the 14 maize genotypes evaluated at the botanical garden are presented in Table 3. The total variation of PCV and GCV showed that, Phenotypic Coefficients of variations (PCV) were higher than the Genotypic Coefficients of variations (GCV) for all the traits measured except molybdenum and zinc which GCV were higher than PCV. The phenotypic variances (σ^2_{ph}) and PCVs were slightly higher than their respective genetic variances (σ^2_{g}) and GCVs for all the traits suggesting some influence of environment in the expression of these characters. Similar results have been reported by Bello *et al*. (2012). Genotypic and phenotypic coefficients of variation (PCV and GCV) showed that all the traits recorded higher values of phenotypic coefficient of variation than genotypic coefficient of variation. This might be due to the fact that there is high environmental effect on the studied genotypes. This observation was in line with that of Mansir (2010) who reported high phenotypic coefficient of variation than genotypic variation in his study on maize. According to Majid (2011), traits having high GCV indicate high potential for effective selection. This indicates the presence of high variability for these traits and provides ample scope for selection of superior genotypes which is in conformity with the findings of Abhirami *et al.* (2005) and Pradeepa (2007). High broad sense heritability estimates were recorded for plant height (0.91), number of leaves (0.78), leaf length (0.95), leaf width (0.95), leaf area (0.95), ears per plant (0.64), anthesis-silking interval (0.88), days to maturity (0.66), boron (0.93) and zinc (0.90), moderate broad sense heritability was recorded for grain yield (0.33), and molybdenum (0.36).

The estimate of Pearson correlation coefficient yield and other agronomic traits for 14 maize genotypes are presented in Table 4. Plant height exhibited significant positive correlation with leaf length (r=0.53), leaf width (r=0.42) and leaf area (r=0.56), and this study contradicts the findings of Jadhav *et al.* (1991) reported that grain yield was significantly and positively correlated with plant height. Number of leaves showed significant positive correlation with leaf length (r=0.64), leaf width (r=0.72) and leaf area (r=0.78). Leaf length exhibited a significant positive correlation on leaf width (r=0.58), leaf area (r=0.82) and boron (r=0.34). Leaf width showed a significant positive correlation on leaf area (r=0.86), leaf area exhibited a significant positive correlation on days to maturity (r=0.36) and ears per plant exhibited a significant positive correlation on grain yield (r=0.50), this contradicts the findings of Biasutti and Peiretti, (1992). Dash *et al.* (1992) reported that yield was significantly but negatively correlated with maturity traits. Molybdenum exhibited positive correlation with boron (r=0.34). The positive correlations between micronutrient concentrations in maize grain suggest that it is possible to improve various micronutrients in maize grain simultaneously.

Table 3: Estimate of Variance Components and Heritability of Maize Genotypes Evaluated for Agronomic Traits and Yield at Keffi in 2018

Traits	σ_g^2	σ_e^2	σ_{ph}^2	PCV	GCV	H	GA	GAM
Plant Height (cm)	9.69	304.88	10.7	31.03	29.52	0.91	1.81	1.63
Number of Leaves	0.93	0.79	1.19	31.67	27.96	0.78	1.58	13.27
Leaf Length (cm)	7.16	71.24	7.40	30.02	29.53	0.97	1.91	2.32
Leaf width (kg)	4.89	0.79	5.15	77.41	75.41	0.95	3.01	34.95
Leaf Area (cm^2)	0.06	0.01	0.06	16.45	16.01	0.95	1.38	59.12
Ears Per Plant	0.15	0.25	0.23	37.95	30.43	0.64	1.43	88.01
AnthesisSilking Interval	0.44	0.42	0.50	44.72	41.95	0.88	2.12	84.74
Days to Maturity	4.20	6.48	6.36	27.22	22.12	0.66	1.24	1.45
Grain Yield (kg/ha)	6.01	3674.34	18.26	38.19	21.92	0.33	0.73	0.59
Mo	0.01	0.02	0.03	39.32	65.57	0.36	0.89	12.92
B	0.01	0.00	0.01	11.37	11.82	0.93	1.36	3.03
Zn	0.71	0.08	0.78	72.28	76.15	0.90	2.15	1.59

σ_g^2 =Genotypic variance, σ_e^2 = Environmental variance, σ_{ph}^2 = phenotypic variance, PCV= Phenotypic coefficient of variation, GCV=Genotypic coefficient of variation, H^2= Broad sense heritability, GA=Genetic Advance, GAM%=Genetic advance as percent of mean, Mo= Molybdenum, B=Boron and Zn= Zinc

Table 4: Correlation Coefficient of Maize Genotypes Evaluated for some Agronomic Traits and yield Evaluated at Keffi in 2018

Traits	PH	NL	LL_	LW	LA	EPP	ASI	DM	GY	Mo	B	Zn
Plant Height (cm)	1.00	0.51	0.53**	0.42**	0.56**	-0.13	0.21	0.27	-0.09	-0.37*	0.16	-0.13
Number of leaves		1.00	0.64**	0.72**	0.78**	-0.13	0.17	0.29	-0.19	-0.06	0.16	-0.01
Leaf Length (cm)			1.00	0.58**	0.82**	0.14	0.12	0.27	0.12	-0.16	0.34*	-0.08
Leaf width (kg)				1.00	0.86**	-0.11	0.13	0.23	0.01	-0.19	0.11	0.06
Leaf Area (cm^2)					1.00	-0.01	0.17	0.30*	0.00	-0.20	0.28	0.02
Ears Per Plant						1.00	-0.25	-0.15	0.48**	0.03	0.11	-0.03
Anthesis-SilkingintervalI							1.00	0.19	-0.08	-0.07	-0.07	-0.16
Days to Maturity								1.00	0.03	0.01	0.13	0.03

Grain Yield (kg/ha)	1.00	0.00	0.22	-0.05
Plant Height (cm)				
Mo		1.00	-0.34*	-0.23
B			1.00	0.19
Zn				1.00

PH= Plant Height (cm), NL= Number of Leaves, LL=Leaf Length (cm), LW=Leaf width (kg), LA= Leaf Area (cm^2), EPP= Ears Per Plant, ASI= Anthesis-Silking Interval, DM= Days to Maturity, GY=Grain Yield (kg/ha), Mo= Molybdenum, B=Boron and Zn= Zinc.

The variation among the fourteen maize collections assessed through principal component analysis evaluated for nine agronomic traits and three mineral compositions. Four of the twelve principal components extracted, had Eigenvalue greater than 1 and accounted for 0.70% of the total variation among the fourteen genotypes (Table 5 and 6). The first principal component accounted for 0.30% of the total variation. The variation in the principal component 1 was mainly attributed to leaf area (0.47), leaf length, leaf width and number of leaves (0.42), plant height (0.36), days to maturity (0.21, boron (0.17), anthesis-silking interval (0.13), zinc (0.00), grain yield (-0.03), ears per plant (-0.06) and molybdenum (-0.16). The principal component 2 contributed 0.19% of the total divergence and depicted the pattern of variation mainly ingrain yield (0.59), ears per plant (0.43), boron (0.24), leaf length (0.15), leaf area (0.05), leaf width and zinc (0.01), days to maturity (-0.01),plant height and molybdenum (-0.05),number of leaves (-0.09) and anther silking interval (-0.14). The principal components 3 constitute 0.11% of the total variation and was mainly attributed to molybdenum (0.55), anthesis-silking interval (0.27), grain yield (0.13), days to maturity (0.12), number of leaves (0.10), leaf length (0.08), leaf width (0.05), leaf area and ears per plant (0.04), plant height (0.00), boron (-0.45) and zinc (-0.61). The principal components 4 described an additional 0.09% of the total variation and was dominated by anthesis-silking interval (0.62), days to maturity (0.34), plant height (0.22), grain yield (0.16), boron (0.15), zinc (-0.12), leaf length (-0.13), leaf area (-0.18), leaf width (-0.21), number of leaves (-0.23), ears per plant (-0.29) and molybdenum (-0.36).

Table 5: Eigen values of the Correlation Matrix of 14 Agronomic Traits and some mineral composition Evaluated

	Eigenvalue	Difference	Proportion	Cumulative
1	3.95	1.42	0.30	0.30
2	2.53	1.10	0.19	0.50
3	1.43	0.29	0.11	0.61
4	1.14	0.16	0.09	0.70

Table 6: Eigenvectors of the Correlation Matrix of 14 Agronomic Traits and some Mineral Composition Evaluated at Keffi, 2018.

Traits	Prin1	Prin2	Prin3	Prin4
Plant Height	0.36	-0.05	0.00	0.22
Number of Leaves	0.42	-0.09	0.10	-0.23
Leaf Length	0.42	0.15	0.08	-0.13
Leaf width	0.42	0.01	0.05	-0.21
Leaf Area	0.47	0.05	0.04	-0.18
EPP	-0.06	0.43	0.04	-0.29
ASI	0.13	-0.14	0.27	0.62
Days to Maturity	0.21	-0.01	0.12	0.34
Grain Yield	-0.03	0.59	0.13	0.16
Mo	-0.16	-0.05	0.55	-0.36
B	0.17	0.24	-0.43	0.15
Zn	0.00	0.01	-0.61	-0.12
Eigen value	3.95	2.53	1.43	1.14
Variation	0.30	0.19	0.11	0.09
Cumulative	0.30	0.50	0.61	0.70

CONCLUSION

The study revealed ample genetic variability for the agronomic traits in the materials used for the study. PCV greater than GCV in the study gave an ample opportunity for selection to take place. High broad sense heritability estimates were high (> 60%) for leaf length and leaf width among the traits studied heritability coupled with low genetic advance as percent of mean, due to relatively small population used in the study. However, the amount of variation and magnitude of gene effects depended on the genetic backgrounds of the materials used in the study. Significant and positive correlation was observed between ears per plant and grain yield and no significant correlation was observed between other traits and grain yield. Generally positive correlations between micronutrient concentrations in maize grain suggest that it is possible to improve various micronutrients in maize grain simultaneously. Further work should be done to elucidate underlying physiological mechanisms of the relation among the micronutrients, particularly in cases when the relations are not obscured by deficiency of any element as an additional complicating factor.

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Marketable Root Bulking, Early Maturity And Best Time For Harvest Sweet Potato Under Rainforest Agro-Ecology Of Umudike, Southestern Nigeria.

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ABSTRACT

Sweet potato is an important carbohydrate root crop grown annually as food security crop. However, many developed sweet potato genotypes vary greatly in their maturity periods. Therefore the objectives of this experiment were to select potential early storage root bulking and maturing genotypes for early sweet potato cultivation genotypes, to have information on precise time for harvesting each genotype and to nominate sweet potato genotypes for extra-early, early, medium and late maturing for various users. Based on this, an experiment was conducted in 2021, laid out in a randomized complete block design with three replications. The 25 plots containing each genotype were replicated 3 times which gave a total of 75 plots. Each plot measured 4 x 3 m and comprised 4 ridges. Ten sweet potato plants from each plot were randomly selected and tagged for harvesting and data collection. Ten sweet potato plants per plot were harvested at the interval of 4 weeks after planting (WAP). Plant attributes studied were number of marketable roots at the proposed harvesting dates of 8, 12, 16 and 20 weeks after planting. The yield data were subjected to analysis of variance and their means and harvest dates were separated with standard error of difference at the probability level of 0.05. The sweet potato genotypes were grouped into four harvest dates proposed as: Very early maturing, early maturing, Intermediate/medium. and Late maturing. Results indicated that sweet potato genotypes vary remarkably in their marketable root bulking and maturity dates. It was evident that bulking was interrupted at 8WAP in all test genotypes and some sweet potato genotypes require more than 16WAP to reach maturity. Therefore it was recommended that harvesting should be at 16 WAP since most sweet potato genotypes possessed marketable root size. Sweet potato genotypes that fall into this group were regarded as medium/intermediate maturing genotypes.

Keywords: marketable roots, harvest time, root number, standard error of difference and sweetpotato genotypes.

INTRODUCTION

The current research effort is geared towards developing not only high yielders but also rapid storage root bulking and early type high starch content sweet potato genotypes. The early maturing types produce yields of high tonnage. The number of storage roots as well as earliness of root bulking and maturity may depend on the genotype, assimilate supply, photoperiod, and temperature (Maini, *et al*., 1977). The process of tuberous root formation and maturity may also depend on soil water supply, soil fertility and soil temperature (Ikpi *et al*., 1986).

Storage root maturity is characterized by leaf area decline and a slow rate of storage root bulking/growth. This phase may not occur in the field when a medium or late maturing genotypes is grown in a short season. Early season storage root initiation and bulking or growth are acceptable for production in areas where sweet potatoes are harvested prior to physiological maturity.

Environmental factors influence storage root bulking. For example, storage root bulking is best promoted by short photoperiods, high light intensity and cool climates, the meteorological factors influencing this process at a given location are basically air and soil temperatures, solar radiation, photoperiod, soil moisture, and crop water use (Githunguri, 2004). According to Nnodu *et al.*, (2006) sensitivity to environmental conditions varies between genotypes. The most limiting environmental factors for sweet potato production are heat and water stresses. Higher temperatures favor above ground biomass development and delay storage root initiation. Leaf senescence is also shortened by high temperatures, especially greater than 30°C as Maini *et al* (1977) reported. Heat stress leads to a higher number of smaller storage roots per plant and reduced dry matter content.

Drought stress limits vine growth and reduces the number of storage roots in larger size categories. Breeding genotypes must be suited to the cropping systems and growing season of a particular region within their agro-ecological area of adaptation. Base on this, storage root bulking information of genotypes at an advanced stage of selection is of great interest for recommendation for testing toward final adoption. Farmers prefer sweet potato varieties which have high yielding and early maturing capacity. The desired attributes of a good early sweet potato types are early storage rooting, rapid storage root bulking and short maturity period coupled with high starch accumulation within a short period before the onset of dry season, good in-ground storability, and good cooking qualities (Nnodu *et al*., 2006). Early storage root bulking keeps pace with crop growth rate. Too early harvest of the sweet potato crop often leads to reduction in storage root yield, while delayed harvest causes development of fibrous, weevil infested storage roots, reduction in starch content and deterioration of root quality (Ntawuruhunga *et al*., 1998). Many factors influence the maturity period of sweet potato however, these factors varied as per each genotype. The optimum stage of harvest, depends on varieties and ecological factors. It was considered desirable to determine the influence of different stages of growth, storage root yield and yield related traits with a view to defining the optimum harvest time for some genotypes. This study aims at selection of potential early storage root bulking and maturing genotypes for early cultivation genotypes and to have information on precise time for harvesting each genotype and to select genotypes for extra-early, early, medium and late maturing for various end users.

MATERIALS AND METHODS

Study site and experiment details: The experiment was conducted in 2021 cropping seasons at Umudike Umuahia Abia State, Nigeria. Umudike is located within latitude 05°17' and 05°27'

North and longitude 05°29' and 07°32' East of the Greenwich Meridian at altitude 122 m above sea level (NRCRI metrology Unit, 2021). It lies in high rainfall forest area of over 2500 mm per annum, with mean photoperiod of 5 hours per day. The temperature is generally high, ranging from 27 to 34°C throughout the year. The average relative humidity is about 76%, with the lowest and highest values in January/December and July, respectively. The soil is typical Ultisol of acid sandy loam soil. The trial was conducted at the Western experimental field of NRCRI, Umudike for assessing storage root bulking maturity of 25 sweet potato genotypes. The site for the experiment was cleared and ridges constructed and spaced 1 m apart. The experiment was laid out in a randomized complete block design with three replications. The 25 plots were replicated 3 times which gave a total of 75 plots, each plot measured 4 x 3 m and comprised 4 ridges. Twenty-five sweet potato genotypes were used for the experiment. Ten genotypes were used as samples per plot per genotype. The sweet potato seed vines were cut 25 cm long, with at least 4 nodes. The seed vines were inserted two nodes° on the crest of the ridges in a slanting position and placed 1 m between ridges and 0.3m apart along the row on the ridges. Thirty plants per plot, equivalent to 33,333 plants per hectare. The seed vines were treated with Decis EC 12 against soil inhabiting pests, especially termites and weevils which attack sweet potato seed vines in the field by dipping and spread under shade for one hour before planting. Weeding was manually done three times, using the West African hoe and hand pulling. Cross bars were constructed to control erosion and conserve soil moisture.

Data collection and analysis

Ten sweet potato plants from each plot were randomly selected and tagged for harvesting and data collection. Ten sweet potato plants per plot were harvested at the interval of 4 weeks after planting (WAP). Plant attributes studied were number of storage roots, length and diameter of storage roots (cm) at 8, 12, 16 and 20 weeks after planting. The yield data were subjected to analysis of variance and their means separated with standard error of difference at the probability level of 0.05. Four harvest dates for the sweet potato genotypes were proposed: Very Early maturing (8WAP), Early maturing (12WAP), Intermediate/medium (16WAP) and late maturing (20WAP).

Evaluation parameters: Marketable root size

Data collected at harvest:

Size of marketable roots: Separate marketable roots i.e., those ≥ 4cm in diameter (>100g). The percentage of marketable roots and number of unmarketable roots were calculated as those less than 4cm or less than 100g

Each harvest date 10 plants from each plot were harvested.

Data Analysis

Marketable root number were analyzed using analysis of variance (ANOVA). Means between harvest dates within test genotypes, and means between test genotypes at each harvest date are compared using standard error of difference. Procedures for performing these comparisons in ANOVA

Data Interpretation

The Storage root bulking stage is a key determinant of the marketable component of total yield, characterized by a constant rate of increase in storage root size. Hence, performance of marketable storage root size across harvest date is of great importance in determining bulking maturity. To assign a test genotype to a given storage root bulking maturity grade, The genotype that did not perform statistically different for marketable storage root number across harvest date in the first harvest date can be regarded as early maturing. The genotypes that perform statistically better in the second harvest date though not significantly different to the third harvest date can be regarded as medium maturing. The genotypes that perform statistically better in the third harvest date can be regarded as late maturing. Genotypes that show no statistical difference in marketable storage root weight in two consecutive harvest dates may show a statistically significant increase in their marketable storage root yield. Since marketable storage root yield is a function of marketable storage root weight and number, a significant increase in marketable storage root yield can be attributed only to a greater number of marketable storage roots. This would be the case of sweet potato genotypes that were able to produce additional storage roots during later stages of plant development or genotypes with more than one storage root setting cycle.

RESULTS AND DISCUSSION

The results from the Table 1 showed a positive significant difference (P = 0.05) for all the four characters: number of storage root, length of storage root, diameter of storage roots and weight of storage root. The highest number of storage root from 8 to 20 WAP for 2020 cropping season was given in Table 1.

Table 1: Number of storage roots of the sweet potato genotypes at 8, 12, 16 and 20 weeks of harvesting in 2020 cropping season

	8 Weeks			12 Weeks			16 Weeks			20 Weeks			
Varietal Name	Large roots	Small roots	Total storage	Large roots	Small roots	Total storage	Large roots	Small roots	Total storage	Large roots	Small roots	Total storage	Mean number of roots
87/OP/132	1	13	14	7	2	9	0	3	3	2	4	6	8.0
PO3/016	0	7	7	7	0	7	0	0	0	2	4	6	5.0
87/OP/145	0	9	9	2	0	2	6	0	6	5	2	7	6.0
NWA/OP/231	0	7	7	4	1	5	7	1	8	0	0	0	5.0
NWA/OP/242	0	19	19	13	0	13	8	0	8	1	3	4	11.0
PO3/93	0	14	14	6`	2	6	6	0	6	7	1	8	9..0
87/OP/194	2	26	28	15	2	17	13	6	19	8	3	11	54.0
PO3/95	3	31	34	16	2	18	11	4	15	8	10	18	21.0
PO3/40	0	29	29	15	0	15	8	4	12	1	3	4	15.0
87/OP/208	0	8	8	16	0	16	9	3	11	3	5	8	10.8
NWA/OP/247	0	36	36	8	1	9	12	8	20	1	8	9	19.0
87/OP/287	0	8	8	7	3	10	6	4	10	3	2	5	8.3
PO3/38	3	14	17	9	1	10	9	3	12	3	4	7	12.0
PO3/119	2	9	11	8	1	9	4	0	4	8	0	8	8.0
NWA/OP/28	0	0	0	0	0	0	0	6	6	1	0	1	2.0
PO3/82	0	12	12	0	0	0	0	1	1	1	1	2	3.8
MAX	0	12	12	2	0	2	3	1	4	1	4	5	5.8
PO3/01/14	2	7	9	8	3	11	12	3	15	0	0	0	9.3
PO3/93	0	14	14	11	4	15	10	4	14	0	2	2	11.3
NWA/OP/290	0	7	7	3	0	3	3	2	5	1	8	9	6.0
PO3/11	0	19	19	9	2	11	8	4	12	3	5	8	13.0
87/OP/210	0	15	15	7	3	10	8	6	14	9	8	17	43.3
TIS87/0087	0	5	5	4	2	6	0	3	3	2	1	3	4.3
Mean	0.5	12.8	13.2	7.4	1.2	8.2	5.7	2.7	8.3	2.8	3.1	5.9	11.6
Range	0-3	0-36	0-36	0-16	0-4	0-18	0-13	0-8	0-20	0-9	0-10	0-18	2.0-54.
Std error	2.0	7.0	=	5.0	2.0	=	1.0	3.0	=	3.0	2.1	=	=

%	3.9	96.1	=	90.2	9.8	=	68.7	31.3	=	47.5	52.5	=	=

Table 1 shows that very few storage roots of each clone reached marketable size at 8WAP. And therefore low marketable storage root yield were recorded. High standard errors for marketable storage roots at 8WAP led to the lack of statistical differences among the sweet potato genotypes for this trait despite the wide range of yield values of 0 to 3.0 with mean number of marketable root of 0.5. The standard error of difference indicated that all the genotypes were still in the same group of immaturity and bulking. The mean number of small roots at 8WAP was high compared to other harvest dates given up to 96.1% of unmarketable root size and 3.9% of unmarketable root size out of the total number of storage root yield. This indicated that the earlier harvest interrupted the bulking rate of the roots reducing the storage root size and render the storage roots unmarketable in all the test sweet potato genotypes. It is likely that most of the genotypes might require more number of weeks to reach maturity. It is not recommended to harvest any of the test genotypes at 8WAP. Table 1 shows that most of the sweet potato genotypes had at 12 WAP produced significantly greater number of storage roots of marketable size. The standard error difference in the number of marketable root potential in the bulking maturity may account for the statistical differences among the genotypes at 12WAP. Although almost all the genotypes showed good number of marketable root size when harvested at 12WAP. The number of marketable root size ranged from 0 to 16 number of storage roots per genotype with mean marketable root number of 7.4 which accounted for 90.2% of marketable root size. If harvesting was to be carried out, the sweet potato genotypes that yielded more than the mean number of marketable roots of 7.4 and were grouped together by the standard error of difference. These should be harvested at 12WAP and these genotypes should be regarded based on the proposed four harvest dates as early maturing. These genotypes included: NWA/OP/242, 87/OP/194, PO3/95, PO3/40, 87/OP/208. These sweet potato genotypes should be of particular importance for areas of short growing seasons, where early harvesting is required.

At 16WAP the genotypes yielded significantly better even though a few marketable roots were harvested, they were not significantly different from those harvested at 12WAP. However, a significant greater number of marketable roots at 16WAP indicated that bulking was still in progress while at 12WAP for most of the genotypes and as such those genotypes could be regarded as intermediate/medium maturing genotypes. The marketable root size ranged from 0 to 13 with mean of 5.7 which accounted for 68.7% of marketable root size while unmarketable root size number accounted for 31.3% of total number of storage roots harvested. This should be expected because some creeping sweet potato genotypes continue to produce storage at the nodes that made contact with the soil.

In contrast, no significant differences was observed for marketable number of roots across harvest dates which indicated that these genotypes could as well be regarded as both early and medium maturing under Umudike conditions. The genotypes grouped by their standard error of difference as belonging to this group were: PO3/145, PO3/93, 87/OP/194, PO3/95, PO3/8, 87/OP/210. Their marketable root yield were above the mean yield of 5.7 number of marketable root yield which accounted for 68.7% of the total number of storage roots harvested.

At 20WAP, few genotypes produced mean marketable roots higher than the mean marketable root of 2.8 which accounted for 31.3% of the total marketable roots yield. This indicated that some of the genotypes could be late maturing. These genotypes were: 87/OP/194, PO3/93, PO3/95, PO3/119 and 87/OP/210. The standard error of difference placed them in late maturing group. The late maturing genotypes have an advantage over the early maturing ones as significantly higher marketable roots can be expected in a late harvest. This is important when farmers need to decide their harvest date according to the markets' demands and supply of sweet potato roots.

The medium/intermediate maturing sweet potato genotypes such as NWA/OP/231 and PO3/01/14 had long senescence and died and could not survive up to 20WAP. The sweet potato genotypes that gave the lowest mean storage roots were NWA/OP/28 of 2.0 numbers of marketable roots while the genotypes with the highest mean number of marketable roots was 87/OP/194 followed by 87/OP/210 and they did well across all the 4 proposed harvest dates by producing significantly high number of marketable roots.

The highest number of storage root from 8 to 20 WAP for the year 2021 cropping season was given in Table 2.

Table2: Number of storage roots of the sweetpotato genotypes at 8,12, 16 and 20 weeks of harvesting in 2021 cropping season

	8 Weeks			12 Weeks			16 Weeks			20 Weeks			
Varietal Name	Large roots	Small roots	Total storage	Large roots	Small roots	Total storage	Large roots	Small roots	Total storage	Large roots	Small roots	Total storage	Mean number of roots across harvest dates
87/OP/132	1	8	9	5	12	17	10	6	16	7	4	11	13.0
PO3/016	0	4	4	5	13	18	13	0	13	6	4	10	11.0
87/OP/145	2	7	9	2	0	2	16	0	16	4	2	6	8.0
NWA/OP/231	0	10	10	2	12	14	17	1	18	1	1	2	11.0
NWA/OP/242	1	11	12	8	15	23	8	0	8	4	1	5	12.0
PO3/93	0	16	16	7`	18	25	6	0	6	9	2	11	15.0
87/OP/194	2	22	24	14	14	28	13	6	19	10	3	13	21.0
PO3/95	1	26	27	8	17	25	11	4	15	8	5	13	20.0
PO3/40	0	23	23	5	10	15	18	4	22	4	1	5	16.0
87/OP/208	0	11	11	9	11	20	9	3	11	5	5	10	13.0
NWA/OP/247	0	28	28	8	13	21	12	8	20	6	4	10	20.0
87/OP/287	0	12	12	7	23	20	16	4	20	4	2	6	15.0
PO3/38	0	16	16	8	11	19	9	3	12	7	4	11	15.0
PO3/119	1	13	14	8	14	22	14	0	14	9	1	10	15.0
NWA/OP/28	0	5	5	0	1	1	0	13	13	5	2	7	7.0
PO3/82	0	2	2	0	0	0	0	10	10	8	3	11	6.0
MAX	0	22	22	0	8	10	7	1	8	7	2	9	12.0
PO3/01/14	1	12	13	5	13	18	12	3	15	2	0	2	12.0
PO3/93	0	12	12	7	14	21	10	4	14	6	1	7	14.0
NWA/OP/290	0	10	10	0	6	6	12	6	18	8	3	11	11.0
PO3/11	0	21	21	6	12	18	18	4	22	4	5	9	18.0

87/OP/210	0	18	18	6	13	19	16	6	22	10	3	13	18.0
TIS87/0087	0	10	10	4	12	16	18	3	21	6	3	9	14.0
Mean	0.4	14.0	14.0	5.0	11.0	16.0	12.0	4.0	15.0	6.0	3.0	9.0	13.0
Range	0-2	2- 28	2-28	0-14	1-23	0-28	0-18	0-8	1-22	2-10	0-5	2-13	6.0-21.0
Std error	0.64	3.82	=	2.32	3.44	=	3.46	2.02	=	2.52	1.61	=	=
%	2.8	97.2	=	33.8	66.2	=	75.2	24.8	=	70.1	29.9	=	=

The result in Table 2 also showed very few mean number of marketable of root of 0.4 in 8 weeks after planting which accounted for 2.8%. The mean number of unmarketable root represented 97.2% of the total roots produced. This suggested that the storage roots of most of the clone genotypes were still bulking and were not yet mature. The number of marketable roots ranged from 0 to 2. The high standard error of difference of 0.64 for marketable root at 8 weeks after planting indicated no statistical difference among the genotypes which showed that they are still in the same group of storage root immaturity and still bulking and therefore cannot be harvested at this stage.

At 12 WAP, the mean number of marketable roots was 5.4 which represented 33.8% while the mean number of unmarketable roots was 11.4 or 66.4% of the total number of storage roots produced. This result indicated that major part of the storage roots were still bulking and immature. The marketable root number ranged from 0 to 14. The standard of error of difference in the number of marketable root potential in the bulking account for statistical difference among the genotypes at 12 WAP. Some genotypes showed marketable root size when harvested at 12 WAP. However, 52% of the genotypes evaluated may be harvested at 12WAP as a result of producing 33.8% of marketable root yield.

At 16 WAP, mean marketable yield number was 11.3 which accounted for 75.2% of the total root yield while mean yield of unmarketable root was 3.9 which represented 24.8%. The marketable root yield ranged from 0 to 18. At this stage, the genotypes yielded significantly better marketable roots potential. The statistical error of difference of 3.46 indicated significant difference means among the test genotypes. However, no significant differences was observed for number of marketable roots across harvest dates as shown by the standard error of difference. This group of genotypes could be assigned as medium maturing genotypes under Umudike agro-ecological condition. Forty-eight percent which yielded more than the grand mean fall under this group.

At 20 WAP yield of marketable roots ranged from 2 to 10 with mean of 6.0 which accounted for 70.1% of total number of storage roots produced that period. This showed that some genotypes were late maturing. The standard of error of difference of 2.52 grouped these genotypes under late maturing genotypes. Thirty-nine percent of the genotypes were under this group.

The duration and rate of storage root bulking in the sweet potato plant determines the yield of the crop. The rate of storage root bulking describe the increase in storage root weight with time, while storage root bulking duration is the time between storage root initiation and persistence of the sweet potato leaves. The decline in leaf area by senescence is as a result of the ceiling in storage root bulking. Although some sweet potato genotypes does not senescence their leaves throughout their growing period. This factor account for yield differences between genotypes. However,

storage root bulking duration is of greater importance as it seems to determine the final yield of sweet potato crop.
Storage root bulking results from two basic processes which include storage root initiation and storage root growth. These two factors is also affected by timing, duration, location, environmental factors, and genotypes.

However, genotypes of medium or late bulking maturity can be recommended for an earlier harvest date provided that the genotype is among those with best marketable storage root weight and yield at the referred date. Therefore, a comparison test between genotypes at a given harvest date is of paramount importance for a final recommendation of the genotype's harvest date. This is of particular importance for areas of short growing seasons, where early harvesting is required.

CONCLUSION

Sweet potato genotypes vary remarkably in their marketable root bulking and maturity. This indicates that earlier harvests would render immature unmarketable size. It is evident that bulking was interrupted at 8WAP in all test clones and it is likely that some of them might require more than 16WAP to reach maturity. Nevertheless, almost all clones showed good marketable tuber weight and number when harvested at 16 WAP. It is therefore recommended that harvesting should be at 16 WAP.

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Proximate Composition of Six Accession of Cocoyam from National Root Crops Research Institute, Umudike

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ABSTRACT

Studies on cocoyam have shown that it is a very important food crop especially in the tropics and subtropics,but little studies have been considered when it comes to its nutritional composition due to the difficulty in accessing its recombinants. This study was carried out to determine and document the nutritional composition of the available accessionsin the cocoyam germplasm of National Root Crops Research Institute, Umudike. Six accessions of cocoyam both (*Colocasia esculenta)* Nce001, Nce012, Nce011 and (*Xanthosoma maffafa*) (Nxs001, Nx002, Nxs003) were harvested,samples were cleaned and oven dried at 50^{0}C and processed into flour.From the findings, NCe001 has the highest significant value of 8.47% and 9.01% for moisture and protein contents respectively. Nx$_s$001 had the highest significant value of 6.33% for fibre content while NX$_s$002 had the least significant value of 2.48% for fibre content.The highest carbohydrate value of 81.28% was recorded for Nx$_s$003. From the findings, these accessions should be recommended to both children and adult as a cheap dietary nutrients source for the promotion of good health. This study also provided important information from the institute's cocoyam germplasm, which can help to develop cocoyam food products and to promote production and utilization of cocoyam by encouraging its sustainability.

Keywords:Cocoyam, proximate composition, accessions and sustainability.

INTRODUCTION

Cocoyams (*Colocasiaesculenta (L.) Schott and Xanthosomasagittifolium (L.) Schott*) are the important species of edible aroids, grown in tropical and sub-tropical countries. Cocoyams are grown mainly for their edible starchy corms, cormels, and their leaves that could serve as vegetables (Aregheore and Perera, 2003). Nigeria is the largest producer of cocoyam in the world, producing 40% of the world output. Cocoyam is eaten in various ways as yam. It can be eaten boiled, fried, pounded into fufu. studies has shown taro flours are rich in starch, total dietary fibre and low in fat, protein and ash contents respectively. Moisture contents are 9.17%; fat contents 3.37% ash contents 2.27% (Apotiola and Fashakin 2013). A high protein contents than most other tropical root crops. Cocoyam appears to be in stiff competition with yam and cassava, which are the preferred tubers for consumption, it is still regarded as an underutilized and insufficiently studied crop (Watanabe, 2002). There is a dearth in information on the nutritional composition of these accessions, it is necessary to analyse each of these accessions and document them This study was carried out to determine and document the nutritional composition of the available accessions in the cocoyam germplasm of National Root Crops Research Institute, Umudike.

MATERIALS AND METHODS

Six accessions of cocoyam both (*Colocasia esculenta)* Nce00*1*, Nce012, Nce011 and (*xanthosoma maffafa*) (Nxs001, Nx002, Nxs003) were harvested from the multiplication field of cocoyam, the Accessions were cleaned(sorted, washed, peeled and chopped into particle sizes) and oven dried at 50^0C and processed into flour and stored in an air tight containers. Proximate analysis was carried out on the different flour samples.

RESULT AND DISCUSSION

Table 1 shows the moisture content ranged from 4.40 to 8.47.There was significant differences among the accessions. Moisture content gives an idea of the storability of the food material, high moisture content depicts high susceptibility to microbial attack and deterioration within a short storage period (Oladebeye*et al.,* 2009). The moisture content of all accessions reported were generally low and corresponds with the report of Oladebeye*et al.*, 2006. Ash content measures the total amount of minerals content in a food crop. The ash content of all the cocoyams used in this study was high suggesting that their flour are rich sources of mineral element of nutritional importance. Crude fibre plays a very important role in nutrition (Olaleye*et al.,* 2013). Evidence has shown that a diet low in fibre is undesirable and could cause constipation, hence many diet are associated with diseases of the colon (pile, appendicitis) the highest crude fibre value was on NX_s001 had the highest significant value of 6.33% while NX_s002 had the least significant value of 2.48%. The values were significantly different from each other and higher than the values reported by Nwanekezi *et al*., (2010). The highest carbohydrate value of 81.28% was recorded for Nx_s003.Fat supplies most of the energies required by man, it is broken down in the body to release glycerol and free fatty acids. The glycerol can be converted to glucose by the liver and used as a source of energy. High amount of lipid present in these accession could be the reason for the fast and high satiety observed when they are consumed. The fat content of the six accessions studied were low when compared to the report of Amandikwa, (2012) but higher than values reported by (Nwanekezi et al., 2010). protein is necessary for good nutrition. Value ranged from 6.03% to

9.01%; there was significant differences ($p<0.05$) among the accessions The crude protein content was high for all the accessions studied. The value compares to the report of Amanze (2009). Carbohydrate supplies energy to body cells, it contributes to fat metabolism and spares protein as an energy source. (Gordon 2000)The highest carbohydrate value of 81.28% was recorded for Nx_s003.The high carbohydrate content is an indication of the high energy reserve inherent in these accessions.The good nutritional value inherent in these accessions, it is good to be recommended to both children and adult as a cheap dietary nutrients source for the promotion of good health.This study also provided important information from the institute's cocoyam germplasm, which can help to develop cocoyam food products and to promote production and utilization of cocoyam by encouraging its sustainability.

Proximate Analysis of Six Accessions of NRCRI Cocoyam

	NXs 001	**NCe 001**	**NXs 003**	**N Ce011**	**NCe012**	**NXs 002**
Moisture %	6.10 c	8.47 a	4.50 e	5.38 d	8.32b	8.32b
Crudeprotein%	8.93a	9.01a	7.24c	5.95 f	6.43d	6.03e
Crude fiber%	6.33a	4.00d	3.72 e	5.27 b	4.59c	2.48e
Crude lipid%	1.10c	1.05d	1.21a	1.15 b	1.22a	1.10c
Ash%	2.50c	2.89b	2.02 f	2.16e	3.79a	2.43d
Carbohydrate%	77.45b	74.58c	81.28a	80.72b	78.61b	80.32a

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Effect of different plant manure sources on growth and yeild of three local varieties of groundnut (*arachis hypogaea l.*) In ishiagu, southeast nigeria.

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ABSTRACT

This experiment evaluated the effect of different plant manure sources on the growth and yield of three local varieties of groundnut (*Arachis hypogaea* L.) conducted at the Research and Teaching Farm of Federal College of Agriculture Ishiagu, Southeast Nigeria during 2020 and 2021 cropping seasons. Three local varieties of groundnut used were; *Nwafum*, *Gwonkworo* and *Oso'obo*, and plant manure sources (*Gmelina*, *Jatropha* and *Neem* leaves) were used as soil amendments at 10 t/ha each in the experiment. A 4 x 3 factorial fitted into randomized complete block design was used in the experiments. The plant manure sources and control were used as Factor A while the varieties served as Factor B. Data were obtained from plant height (cm) and number of leaves at 3, 6, 9 and 12 weeks after planting, number and weight (kg) of pods and number of galled roots at harvest. Data obtained were averaged over the two years and subjected to analysis of variance (ANOVA) using GENSTAT 3 Edition 7.2. Significant treatment means were separated using Least Significant Difference (LSD) at 5% level of probability. Results indicated that the plant manure sources significantly ($P<0.05$) increased the plant height, number of leaves at 3 and 6 weeks after planting, number and weight (kg) of pods at harvest over the control. The plots amended with *Jatropha* leaves gave the highest plant height, number of leaves, number and weight of pods. It is therefore recommended that the plant manure sources used in this experiment could be employed in the production of groundnut with more emphasis on *Jatropha* leaves.

Key words: plant manure; local; groundnut; yield

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important food and forage crop because of its high protein and oil contents. Its seed is used as a source of cooking oil and in confectionary products for human consumption. Groundnut hay (vine) is a nutritious animal feed, particularly for the subsequent dry season when green forage is not available. In addition, groundnut seed and hay are often sold in local markets, providing income to the resource-poor farmers (Alabi *et al.*, 2003).

Groundnuts usually grow well in light sandy to sandy-loam, well-drained, aerated soil but heavy soils or soils with a tendency to form crust are unsuitable because they hamper the penetration of the pegs during flowering and impact negatively on harvesting (Waele and Swanevelder, 2001). Hack (1997) observed that heavy clay soils make harvesting difficult, reduce yield through fracture and pod may be strained by adhering clay. Interestingly, groundnuts will grow in heavier soils according to Tweneboah (2000) if there is no water logging and if the surface soil is loose enough to allow penetration of the ovary. Farmers have general preference for well drained, light sandy loams because of ease of cultivation and harvest.

Groundnut is grown either as a sole crop or intercropped with maize or sorghum. The cultivation of the crop started in irrigated agriculture, but later spread to the dry land cropping system. Groundnut germinate in 3 to 6 days. It grows rapidly on fertile soils with leaf development proceeding rapidly. Soil conditions in dry land farming are considered more favorable for groundnut production. The seed contains 50 to 52% oil and 24 to 25% protein. Though the seed is generally roasted and eaten as a snack, there is great potential for oil extraction (Abbiw, 1990).

Nutrient management is always an important consideration for groundnut production because it requires large quantities of nutrient, especially potassium is one of the most limiting factors for groundnut production (Basiron, *et al.*, 2000).

Therefore, continuous cultivation of a crop like groundnut on the same land will lead to soil mining, degradation of soil quality and consequent low yield. For optimum target yield, there is the need for fertility enhancing technologies including the integrated application of organic manure/amendments that will ensure immediate nutrient release for the present crops as well as the long term build up of soil nutrients.

High cost of fertilizer and increasing concern for ecological stability and sustainable soil productivity have led to renewed interest in plant manure (Jibrin 2002, Fageria, 2007). In many parts of West Africa, *Mucuna* has been adopted as a low input strategy for addressing the problem of declining soil fertility arising from population pressure, intensive cultivation and shortening fallow periods (Mahmoud, *et al.*; 1992). Some leguminous Plant manure crops have the ability to accumulate high amount of N within a short time.

The objective of this study was to determine the effects of different plant manure sources on the growth and yield of three local varieties of groundnut produced in Ebonyi state, Nigeria.

MATERIALS AND METHODS

Description/Location of Experiment Allocation

The experiment was conducted at the Research and Teaching Farm of Federal College of Agriculture, Ishiagu, Ebonyi State, during the 2020 and 2021 cropping seasons. The study area lies within latitude 05^0 56'N and longitude 07^0 41'E in the derived savannah zone of the Southeastern Nigeria. The area has a mean annual temperature of about 30 ^{0}C and rainfall of 130mm (Federal College of Agriculture Ishiagu, 2013). Geologically, the area is underlain by sedimentary rock and lies within Asu River Group (Nwite *et al*., 2014).

Experimental Design/Treatment Allocation

The experimental design was a 4 x 3 factorial fitted into randomized complete block design replicated three times. The plant manure sources constituted factor A while varieties were factor B. The treatments used were; older leaves Neem, *Gmelina* and *Jatropha* at10 t/ha each. The plots without amendment served as control. The three local groundnut varieties used were; *Nwafum, Gwonkworo,* and *Oso'obo*.

Factor A were plant manure sources (Control, *Gmelina, Jatropha* and Neem leaves) formed the main plot while Factor B were local groundnut varieties (*Nwafum, Gwonkworo,* and *Oso'obo*) constituted the sub-plots. These local groundnut varieties used for the research were the local best obtained from farmers in Ishiagu, Ivo Local Government Area of Ebonyi State.

Field Preparation

The experimental sites were cleared, ploughed, harrowed and later made into beds using native hoe. The net plot size was 2 m X 2 m. The different plant manure sources were randomly allocated to the main plots and were incorporated into the soil and left for two weeks before planting. The un-amended plots served as the control. The local groundnut varieties were randomly allocated to the sub-plots and were planted at the spacing of 30 cm X 40 cm with two (2) seeds per hole giving a projected plant population of 83,333 stands per hectare. Two weeding operations were carried out manually with weeding hoe and hand pulling at two and five weeks after planting. At six (6) weeks after planting, the plants were earthened up in each year.

Data Collection

Ten plants were randomly selected from each variety and tagged for data collection each year. Data were collected on the following parameters:.

a. Plant height at 3 weeks, 6weeks, 9 weeks and 12 weeks after planting (WAP).
b. Number of leaves at 3, 6, 9 and 12 weeks after planting
c. Number of pods at harvest
d. Weight (kg) of pods at harvest.

Statistical Analysis

Data collected were averaged over the two years and subjected to the analysis of variance (ANOVA) according to the procedure for the factorial in a randomized complete block design (RCBD) using GENSTAT 3 Edition 7.2. Significant treatment means were separated and compared using least significant different (LSD) at 5% probability level as outlined in Obi(2002).

RESULTS

The physical and chemical properties of the soil before application of amendments are shown on Table 1. The soil is sandy clay loam with a total percentage of sand as 60.9%, 17.9% silt and 21.2% clay. The soil is slightly acidic with a pH of 4.8. The organic carbon and total nitrogen of the soil were 0.98% and 0.41% respectively. The analysis indicated that the studied soil was moderate in exchangeable bases. In addition, the cation exchange capacity was low, also with the amendable phosphorus (23.1 mg/kg) in the studied soil. Some of the chemical components of the soil before used for planting showed that N, P, K, Ca, Mg, Na and OC were of low values which revealed that the soil is low in fertility.

Table 1: Physical and chemical properties of the studied Soil (0-20cm).

Properties	Values
Sand (%)	60.90
Silt (%)	17.90
Clay (%)	21.20
Textural class	Sandy clay loam
pH (H_2O)	4.8
Organic Carbon (%)	0.98
Total nitrogen (%)	0.41
Exchangeable bases (cmol/kg)	-
Sodium	0.4
Potassium	0.19
Calcium	3.20
Magnesium	0.80
Available phosphorus (Mg/kg)	23.1
Base saturation (%)	66.43
Exchangeable acidity (cmol/kg)	2.32
Organic matter (%)	1.68
ECEC (cmol/kg)	6.91

The results in Table 2 show that the plant heights were significantly ($P<0.05$) affected by the plant manure sources and varieties at 3 and 6 weeks after planting (WAP). The interaction of the Plant manure sources and varieties had significant ($P<0.05$) effect on the plant height at 3 WAP only. The highest plant heights were obtained from plots amended with *Gmelina* leaves (46.79 cm), Gwonkworo (43.31 cm) and the interaction of Plant manure sources by varieties (48.97 cm). The lowest plant heights were obtained at the control plots.

Table 2: Effect of treatments on plant height (cm) at 3, 6, 9 and 12 weeks after planting (WAP)

Treatments	3 WAP	6WAP	9WAP	12WAP
PMS				
Control	11.03	21.65	30.02	39.18
Gmelina	11.49	23.68	33.28	46.79
Jatropha	12.73	24.60	32.11	41.53
Neem	12.15	21.65	31.34	41.48
$LSD_{0.05}$	0.99	2.14	NS	NS
Variety				
V1	8.43	20.04	29.67	40.21
V2	14.06	23.39	33.23	43.31
V3	13.06	25.25	32.17	43.22
$LSD_{0.05}$	0.86	1.86	NS	NS
PMS X Variety				
Control X V1	7.44	18.06	29.33	39.47
Control X V2	13.21	22.12	31.40	43.33
Control X V3	12.43	24.75	29.33	41.80
Gmelina X V1	8.53	22.17	31.70	48.97
Gmelina X V2	14.04	23.74	32.80	44.80
Gmelina X V3	11.92	25.14	35.33	46.60

Jatropha X V1	9.29	22.47	29.97	34.95
Jatropha X V2	14.31	24.60	35.58	44.10
Jatropha X V3	14.60	26.73	30.77	38.50
Neem X V1	8.47	17.47	27.67	37.47
Neem X V2	14.69	23.09	33.13	41.00
*Neem*X V3	13.30	24.38	33.23	45.97
$LSD_{0.05}$	1.72	NS	NS	NS

NS= Non Significant; PMS = Plant manure Sources; V1=Nwafum, V2=Gwonkworo and V3=Oso'obo

The results in Table 3 show that the plant manure sources significantly (P<0.05) affected the number of leaves produced by the plants at three (3) weeks after planting. The number of leaves produced significantly (P<0.05) varied amongst the varieties at 3, 6, 9 and 12 WAP. The interactions between plant manure sources and varieties have significant (P<0.05) effects on the number of leaves produced by the plants.

Table 3: Effect of treatments on Number of leaves at 3, 6, 9 and 12 WAP

Treatments	3 WAP	6WAP	9WAP	12WAP
PMS				
Control	79.20	312.50	646.00	397.00
Gmelina	100.10	373.00	705.00	409.00
Jatropha	90.90	323.00	651.00	454.00
Neem	87.10	333.70	656.00	436.00
$LSD_{0.05}$	3.71	NS	NS	NS
Variety				
V1	71.0	265.30	577.00	355.00
V2	96.10	415.40	774.00	652.00
V3	100.90	326.00	643.00	285.00
$LSD_{0.05}$	7.54	20.98	13.10	18.13
PMS X Variety				
Control X V1	62.50	236.50	551.00	309.00
Control X V2	83.20	402.00	733.00	604.00
Control X V3	91.80	299.00	655.00	277.00
*Gmelina*X V1	87.10	335.30	665.00	325.00
*Gmelina*X V2	102.30	445.90	803.00	654.00
*Gmelina*X V3	110.30	337.80	646.00	247.00
*Jatropha*X V1	71.20	246.60	569.00	361.00
Jatropha X V2	99.00	407.10	790.00	720.00
Jatropha X V3	102.40	315.40	595.00	280.00
Neem X V1	62.40	242.70	522.00	345.00
Neem X V2	99.80	406.50	770.00	628.00
*Neem*X V3	99.00	351.80	677.00	334.00
$LSD_{0.05}$	3.67	23.07	12.09	17.98

NS = Non Significant; GMS = Plant manure Sources; V1=Nwafum, V2=Gwonkworo and V3=Oso'obo

The results in Table 4 show the effect of the treatment on number and weight of pods at harvest. The results obtained showed that the Plant manure sources significantly (P<0.05) affected the number and weight of pods at harvest. The highest number of pods (42.90) and weight of pod

(1.54kg) were obtained from the plots amended with *Jatropha* leaves. The lowest number of pods (26.60) and weight of pods (0.53kg) were obtained from the control plots.

Table 4: Effect of treatments on Number and Weight (kg) of pods at harvest

Treatments	Number of pods	Weight (kg) of Pods
PMS		
Control	26.60	0.53
Gmelina	40.60	1.18
Jatropha	42.90	1.54
Neem	36.20	1.23
$LSD_{0.05}$	7.23	0.26
Variety		
V1	33.70	1.08
V2	37.90	1.35
V3	38.10	1.09
$LSD_{0.05}$	NS	NS
PMS X Variety		
Control X V1	22.00	0.53
Control X V2	29.00	0.87
Control X V3	28.70	0.80
Gmelina X V1	36.00	1.27
Gmelina X V2	40.00	1.33
Gmelina X V3	45.30	0.93
Jatropha X V1	49.00	1.37
Jatropha X V2	40.30	1.77
Jatropha X V3	39.30	1.50
Neem X V1	27.70	1.13
Neem X V2	42.00	1.43
*Neem*X V3	39.00	1.13
$LSD_{0.05}$	5.67	0.14

= Non Significant; GMS = Plant manure Sources; V1=Nwafum, V2=Gwonkworo and V3=Oso'obo

DISCUSSION

The experimental soil was sandy clay loam with a total percentage of sand as 60.9%, 17.9% silt and 21.2% clay. The soil was slightly acidic with a pH of 4.8. The organic carbon and total nitrogen of the soil were 0.98% and 0.41% respectively. The analysis indicated that the studied soil was moderate in exchangeable bases. In addition, the cation exchange capacity was low, also with the amendable phosphorus (23.1 mg/kg) in the studied soil. Some of the chemical components of the soil before used for planting showed that N, P, K, Ca, Mg, Na and OC were of low values which revealed that the soil is low in fertility.

The increase in plant height across the weeks was attributed to the relative decay periods of the plant manures and the absorption rates of the nutrients released by the varieties. This is in line with the works of Mukhtar *et al*. (2014) who stated that organic manures as valuable by-products of farming and agro-allied industries, contribute to plant growth through their favourable effects on the physical, chemical and biological properties of soil and nutrient availability.

The increase in the number of leaves shows that the nutrients contained in the leaves used as soil amendment were released on decomposition to the plants for vegetative growth which led to increase in the number of leaves produced by the plants on the treated plots.

The increase in the number and weight of pods from the treated plots showed marked effects of the plant manures sources when compared with that obtained from the control plots. These indicated that plants utilized the products from the decomposition of the various plant manures which increased their matter content. Ajari *et al*. (2000) reported that nutrient absorption by plants facilitates normal physiological function and photosynthetic processes, which made the plants to posses the ability to increase yield. Sonbeer *et al.* (2017) and Falodun and Egharevbra (2018) also reported enhanced growth and yield of onion and carrot in soil amended with *Jatropha* leaves.

CONCLUSION

The results of the experiment revealed that the Plant manures sources used could be employed in enhancing the growth and yield parameters of the three groundnut varieties. *Jatropha* and *Gmelina* leaves showed better effects than neem leaves though not statistically different. They could be employed as veritable alternatives to organic fertilizers in the production of groundnut.

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Awareness of insect pest infestation during production and storage of three neglected crops in selected states of Southern Nigeria

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ABSTRACT
Insect pest infestation affects crops during production and storage, thereby leading to food insecurity. The study was conducted to examine the farmers' awareness of insect pest infestation during production and storage of three neglected food crops (bambaragroundnut, breadfruit and bush mango) in Southern Nigeria. A purposive technique was used to sample 120 farmers of the selected neglected crops in Akwa-Ibom, Ebonyi and Rivers states.. A well-structured questionnaire was used to obtain information from the respondents and analyzed using descriptive statistics. The result revealed that the mean age of neglected food crops farmers in the study area was 41 years, with 65% of them being females. Their averagefarming experience was 11.4 years and the mean farm size was less than 1 hectare. The results revealed that 41.7% of the respondents are aware of insect pests as a major production constraint while 65% of the respondents stored their crops in bags/sacks. Findings revealed that 33.3% of the farmers encountered insect pest infestation as a major storage constraint. The insect pests encountered in storage are weevils (25.8%) and beetles (13.3%) and the coping strategy to reduce the spoilage during storage in the area were early sales (70.8%) and consumption (69.2%). The common pests identified were *Callosobruchus maculatus* and *Oryzaephilus mercator*. This study recommends that more researches into post-harvest technology related to the selected food crops be carried out

INTRODUCTION
In Nigeria, peasant farmers constitute a high proportion of farming population with the output still insufficient to feed the population of about 217 million people (Ojeka*et al.*, 2016; Worldometer, 2022). Post-harvest loss in Nigeria is estimated to be 20-30% of the total production (World Bank, 2011). Jaspareet and Anita (2013) reported that the food consumed is lesser than the food lost or

wasted. Food insecurity, poor nutritional value, reduction in farmers' income, and lack of input for the next production are some of consequences of post-harvest losses (Olayemi*et al.*, 2011).
Insect pest infestation is one of the major causes of food insecurity in Sub-Saharan Africa (Nwaubani*et al.*, 2014). Insect pests are responsible for deterioration and destruction of food products (Silva-Aguayo *et al.*, 2004). Insect damage causes serious losses to grain famers during storage (Nwaubani *et al.*, 2014) through reduction in quality and quantity of food available for human consumption (Okonkwo *et al.*,2017). Peasant farmers and grain aggregators in Sub-Saharan African are frequently forced to sell their crops at giveaway prices due to lack of effective ways to control insect pests during storage (Stathers*et al.*, 2008; Nwaubani *et al.*, 2014).
Most of important crops in South-South and South-East regions of Nigeria have been neglected and underutilized due to oil discovery in area and this has reduced most of the resources to be used in agriculture (Matemilola and Elegbede, 2017). In Nigeria, neglected crops receive little research attention, poor communication, marketing, lack of effective policy frame works for harnessing their potentials (Idowu, 2009). Hence, there is need for more reliable data that can explore some of the potentials of these neglected crops. The objectives of this study are to;ascertain the socio-economic characteristics of farmers;identify the insect pestchallenges encountered during the production andstorage of some neglected food crops; identify the storage methods used by the farmers and identify ways of solving challenges during storage ofthese neglected food crops in the study area.

METHODOLOGY

The study was carried out in three States in Southern Nigeria; Akwa-Ibom (4.9057^{0}N, and 785370E), Ebonyi (6.2649^{0}N, 8.0137^{0}E)and Rivers (4.8396^{0}N, 6.9112^{0}E), between May and June 2021. The study population consists of farmers cultivating the selected neglected crops (bambara groundnut, breadfruit and bushmango).A multistage purposive sampling procedure was used for this study. The first stage involved purposive selection of three states, two from the South-South (Akwa-Ibom and Rivers States) and one from the South-East (Ebonyi) where the three selected cropsweregrown. The second stage involved liaising with Agricultural Development Programme (ADP) in each state through their extension agents for the selection of 4 local governments in each state where the selected crops are grown to make 12 Local Government Areas(LGAs) consisting of Abak, Ibiono-Ibom, Itu, Oruk-Anam, Ezza-South, Ikwo, Ishielu, Ohankwu, Degema, Abua-Odual, Ahoda-East, and Asari-Toru.Afarming community was selected from each L.G.A. to make 4 communities in a state and a total of 12 communities in the three selected states. In each community, 10 farmers that grow any of the crops were selected, giving, a total of 40 respondents in a state and 120 respondents in the 3 states selected. Data were collected from the respondents through the use of structured questionnaires and were analyzed using frequency and percentages.

RESULTS AND DISCUSSION

Table I: Distribution of farmers of neglected food crops according to socio-economic characteristics (N= 120)

Socio-Economic Characteristics	Frequency (Percentage)Mean

Age (Years)	F (%)	Mean
20-29	18 (15)	
30-39	43(35.8)	
40-49	35 (29.2)	41
50-59	15 (12.5)	
60-69	5 (4.2)	
70-79	4 (3.3)	
Sex		
Female	78 (65)	
Male	42 (35)	
Years of Business Experience		
1-5	15(12.5)	
6-10	45 (37.5)	11.4
11-15	38 (31.7)	
16-20	7 (5.8)	
21-25	15 (12.5)	
Farm Size		0.3812 hect.

Source: NSPRI Field Survey, 2021

Table 1 shows that the mean age of the neglected food crop farmers in the study area was 41 years, with 65% of them being females. Their average farming experience was 11.4 years while their average farm size was 0.3812 hectare, a figure considered too low for commercial crop production. The finding also implies that the farmers of the neglected crops in the study area are in their active ages, more energetic and productive, and they are conversant with the crops limitations and benefits because the respondents are less than 50 years of age and have business experiences of more than 10 years. This supports the findings of Elemasho *et. al.* (2017) who reported that, young farmers are more willing to adopt new innovation than elders because the young farmers are more open to innovations, willing to adopt new technology and are not afraid of taking risks.This is tandem with the findings of Ojeka*et al.*, (2016) who reported that Nigerian farmers'output is not enough to feed her population because each farmer on the average cultivates less than 5 hectares using simple tools and traditional methods for production.

Table 2: Distribution of farmers according to the kind of neglected food crops produced (N= 120)

Neglected food crops	Frequency (F)	Percentage (%)
Bambaragroundnut	25	20.8
Breadfruit	30	25
Bushmango	65	54.2
Total	**120**	**100**

Source: NSPRI Field Survey, 2021.

Table 2 indicates that 20.8% of the neglected food crop farmers in the study area produced bambara groundnut, while 25% were breadfruit farmers and 54.2% were bush mango farmers. The majority of the farmers in the study area engaged in Bushmango farming and this supports the findings of Chah *et al*. (2014) who reported that Bushmango as important non-timber forest product in Southern Nigeria.

Table 3: Distribution of farmers according to insect pestchallenges during production (N= 120)

Selected neglected crops	Yes F (%)	No F (%)
Bambara groundnut	20 (16.7)	5 (4.2)
Breadfruit	1 (0.8)	29 (24.2)
Bush mango	29 (24.2)	36 (30)
Total	**50 (41.7)**	**70 (58.3)**

Source: NSPRI Field Survey, 2021. % = Percentage, (F) = Frequency

Table 3reveals that 41.7% of the farmers acknowledged that insect pests attack these neglected crops on the field. This supports the findings of Uddin II *et al.* (2017) and Baudoin & Mergeai (2001), who reported insect pest attack on bambaragroundnut on the farm at different developmental stages. In a similar study, Germain *et al.* (2010) reported insect pest infestation on bush mango.

Table 4: Distribution of farmers according to the method of storage of the selected neglected food crops (N= 120)

Method of storage	Crops	Yes F (%)	No F (%)
Bag/Sack	Bambara groundnut	25 (20.8)	0 (0)
	Breadfruit	10 (8.3)	20 (16.7)
	Bushmango	58 (48.3)	7 (5.8)
	Total	**93 (77.5)**	**27 (22.5)**
Container	Bambara groundnut	25 (20.8)	0 (0)
	Breadfruit	10 (8.3)	20 (16.7)
	Bushmango	42(35)	23 (19.2)
	Total	**77 (64.2)**	**43 (35.8)**

Source: NSPRI Field Survey, 2021. % = Percentage, (F) = Frequency

Table 4indicates that 77.5% of the respondents stored their crops in bags/sack while64.2% of the respondents indicated container (drum, gallon, etc). This study supports Babarinde *et al.*, (2016), who found out that majority of crop stakeholders stored their produce in sacks.

Table 5: Distribution of farmers according to the insect pests responsible for the storage challenges of the selected neglected food crops (N= 120)

Causes of storage challenges	Crops	Yes F (%)	No F (%)
Insect	Bambara groundnut	24 (20)	1 (0.8)
	Breadfruit	2(1.7)	28 (23.3)
	Bushmango	14 (11.7)	51 (42.5)
	Total	**40 (33.3)**	**80 (66.7)**

Source: NSPRI Field Survey, 2021. F = Frequency, % = Percentage

Table 5shows that 33.3% of the farmers are aware of losses due to insect pest infestation on their produce during storage, out of which 20% were for bambara groundnut farmers 16.7% from bushmango farmers and 1.7% from breadfruit farmers. This supports Hodges *et al.* (2014) who stated that biological agents such as insects cause post-harvest losses.

Table 6: Distribution of farmers according to the type of insect pest encountered during storage of selected neglected food crops (N= 120)

Types of insect	Crops	F	%
Weevil	Bambara groundnut	25	20.8
	Breadfruit	1	0.8
	Bush mango	5	4.2
	Total	**31**	**25.8**
Beetle	Bambara nut	0	0
	Bread-fruit	1	0.8
	Bush mango	15	12.5
	Total	**16**	**13.3**

Source: NSPRI Field Survey2021. F = Frequency, % = Percentage

Table 6reveals that 25.8% of the neglected crop farmers encountered weevils during storage while 13.3% encountered beetles. The insects reported in bambaragroundnut and bush mango by e farmers are cowpea weevil (*Callosobruchus maculatus*) and merchant grain beetle(*Oryzaephilus mercator*). This supports the findings of Mbah-Omeje *et al.*(2019) who reported that weevil is the primary pest of bambaragroundnut while Mbah *et al.* (2015) reported beetle as the primary pest of bush mango.

Table 7: Distribution of farmers according to the method of minimizing losses from insect pests during storage of selected neglected food crops (N= 120)

Solution to challenges	Crops	Yes F (%)	No F (%)
Early sales	Bambara groundnut	18 (15)	7 (5.8)
	Bread fruit	22 (18.3)	8 (6.7)
	Bush-mango	45 (37.5)	20 (16.7)
	Total	**85 (70.8)**	**35 (29.2)**
Consumption	Bambara groundnut	20 (16.7)	5 (4.2)
	Breadfruit	15 (12.5)	5 (4.2)
	Bush-mango	48 (40)	17 (14.2)
	Total	**83 (69.2)**	**27 (22.5)**

Source: NSPRI Field Survey, 2021. F = Frequency, % = Percentage

Table 7 shows that 70.8% of the farmers used early sales technique to minimize losses from insect pest infestation during storage while 69.2% of the farmers adopted consumption of the produce. This supports Olayemi*et al.* (2011) who reported that farmers adopted early sales to reduce storage problems from insect pests.

CONCLUSION

Findings from this study showed that farmers of selected neglected food crops in the study area were experiencing production and storage limitations due to insect pest infestation, and the methods used in minimizing the losses by the farmers will reduce the their income. Findings from the study recommend that more researches into post-harvest technology related to the selected food crops be carried out.

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Evaluation of different organic wastes on quality of turmeric seed production in Umudike, Nigeria

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ABSTRACT

Climate variability has resulted to soil depletion and low yield of turmeric. There is need for soil amendment with organic waste which is reported to improve soil nutrient use efficiency in crops. This study evaluated the potentials of different compost manure in enhancing the yield, curcumin, and total carotenoid content of turmeric species, *curcumin longa*. Composts evaluated were poultry manure, cow dung, pig waste and cocoa pod, applied at the rate of 6 t/ha one week before planting. NPK fertilizer applied at the rate of 200 kg/ha was used as the standard to compare the organic waste and absolute control (no fertilization). The experimental design was RCBD with 4 replications. Harvested turmeric rhizomes were analyzed for yield, total curcuminoids and total carotenoids. The result of the yield showed poultry manure (22.28 t/ha) > cow dung (20.66 t/ha) > cocoa husk (20.39 t/ha) > swine waste (16.17 t/ha) > NPK (10.61 t/ha) > zero application (3.11 t/ha). Curcumin content was not enhanced by any of the manure, whereas total carotenoid content was enhanced by NPK (3192 µg/g) > cocoa husk (3189 µg/g) > cow dung (3087 µg/g) > poultry manure (2724.5 µg/g) > swine waste (2630.0 µg/g) > zero fertilizer (2542.0 µg/g). Therefore, for sustainable turmeric seed production, compost manure is highly recommended.

Keywords: Turmeric, compost manure, yield, curcumin, carotenoids

INTRODUCTION

Two species of turmeric (*curcuma longa Linn* and *Curcuma xanthorriza*) are perennial crops cultivated in the tropical countries. They are used as spices to add flavour and colour to food, *longa* specie is a major constituent of curry powder giving it the reach golden yellow colour. Both species of turmeric are of great medicinal values (Ortega, and Campos, 2019). Curcumin, a polyphenolic compound found in turmeric is responsible for the numerous health benefits associated with it.

Turmeric consumption is mainly because of the associated health benefits therefore, it is imperative that any interventions mitigated towards increasing turmeric yield should also increase the bioactive compounds in turmeric which is high curcumin and carotene content.

Turmeric crop requires fertilization to improve yield and globally there is a shift from inorganic to organic fertilizers. Organic fertilizers and manures have been reported by several authors to improve soil health and nutrient use efficiency in root and tuber crops, enhance improving the yield. In addition to being cheaper and very readily available to farmers (Olojede *et al.*, 2022; Senobi, 2010; Njoku *et al.*, 2014). This study seeks to find out which of the organic liquid fertilizers and compost manures has the best potential to enhance turmeric yield as well as curcumin and total carotenoid content.

MATERIALS AND METHODS

Two turmeric species (*Curcuma longa and Curcuma xanthorrhiza*) grown with different organic fertilizers were evaluated for yield, curcumin, and total carotenoids content. The fertilizers consisted of four organic waste manure (poultry manure, cow dung, pig waste and cocoa pod) applied at the rate of 6 t/ha one week before planting and two foliar liquid fertilizers (black diamond and boost extra) applied at 100mls in 15 liters of water one month after planting. NPK fertilizer applied at the rate of 200 kg/ha was used as the standard to compare the organic waste and absolute control. The experimental design used was RCBD with 4 replications. The roots of harvested turmeric were analyzed for total curcuminoids using the methods described by Anindya *et al.* (2015), total carotenoids using the method described by Mieko and Delia (2003) and yield. Data were subjected to ANOVA and significant means separated at 5% level.

RESULTS AND DISCUSSION

Table 1 reveals the result of the effect of fertilization on curcumin accumulation in *longa* specie. From the result it is seen that highest curcumin was found in longa with zero fertilizer application, and this was not significantly different from what was obtained in the groups treated with swine waste and poultry manure. NPK, cocoa husk, boost extra and black diamond reduced the amount of curcumin accumulated compared to the negative control which is the zero-application group. However, in *xanthorrhiza* specie (Table 2), treatment with black diamond, boost extra and NPK enhanced curcumin accumulation compared to the negative control without treatment. Comparative analysis of curcumin content in both species (Table 3) reveals that more curcumin is domiciled in *longa* specie than *xanthorrihza* specie.

For total carotenoid content, we observed that of the two species, *xanthorrihza* contains higher carotenoid than *longa* expecially in *xanthorrihza* with no treatment, while *longa* treated with boost extra, black diamond and NPK gave an appreciable amount of carotenoids content (Table 4).

Table 5 reveals that fertilization significantly increased yield of turmeric. However, the yield of *longa* was much higher than that of *xanthorrihza,* it was observed that poultry manure and cow dung was responsible for this high yield (Table 5).

CONCLUSION

Longa specie contains higher curcumin and there is no need for fertilizer application if the interest is to cultivate longa for high curcumin. *Xanthorrihza* requires no treatment for high carotenoid, but longa does, and organic liquid fertilizers (boost extract and black diamond) are advised. To obtain a combination of high yield with high carotenoid we propose longa variety with poultry manure or longa with cow dung. Finally, if interest is on vitamin A intervention in addition to high yield, we propose *xanthorrihza* produced with boost extract.

Table 1 Effect of treatments on curcumin content of Curcuma longa

Treatment	Curcumin (%)	Groups
Longa + zero application	3.190	a
Longa + swine waste	3.170	a
Longa + poultry manure	3.145	a
Longa + cow dung	3.055	b
Longa + NPK	2.98	bc
Longa + cocoa husk	2.975	bc
Longa + boost extra	2.97	bcd
Longa + black diamond	2.925	cde

Table 2: Effect of treatments on curcumin content of Curcuma xanthorihza

Treatment	Curcumin (%)	Groups
Xanthorihza + black diamond	3.045	b
Xanthorihza + NPK	3.035	bc
Xanthorihza + Boost extra	3.025	bcd

Xanthorihza + zero application	2.955	e

Table 3: Comparative effect of treatments on curcumin content of longa and xanthorihza varieties

Sample	Curcumin (%)	Groups
Longa + zero application	3.190	a
Longa + swine waste	3.170	a
Longa + poultry manure	3.145	a
Longa + cow dung	3.055	b
Xanthorihza + black diamond	3.045	b
Xanthorihza + NPK	3.035	bc
Xanthorihza + Boost extra	3.025	bcd
Longa + NPK	2.98	cde
Longa + cocoa husk	2.975	cde
Longa + boost extra	2.97	de
Xanthorihza + zero application	2.955	e
Longa + black diamond	2.925	e

Table 4: Comparative effect of treatments on total carotenoids content of longa and xanthorihza varieties

Treatment	Carotenoids (µg/g)	Groups
Xanthorihza + zero application	3233.0	a
Longa + boost extra	3215.0	b

Longa + black diamond	3204.5	c
Longa + NPK	3192.0	d
Longa + cocoa husk	3189.0	d
Xanthorihza + Boost extra	3164.0	e
Xanthorihza + black diamond	3108.0	f
Longa + cow dung	3087.0	g
Xanthorihza + NPK	2949.5	h
Longa + poultry manure	2724.5	I
Longa + swine waste	2630.0	J
Longa + zero application	2542.0	k

Table 5: Comparative effect of different organic treatments on yield of longa and *xanthorihza* species

Treatment	Fresh Rhizome (t/ha)	group
Longa + poultry manure	22.28	a
Longa + cow dung	20.67	a
Longa + cocoa husk	20.39	ab
Xanthorihza + Boost extra	18.57	ab
Longa + swine waste	16.17	bc
Xanthorihza + black diamond	12.78	cd
Xanthorihza + NPK	11.33	de
Longa + NPK	10.61	ef
Xanthorihza + zero application	8.0	efg

Longa + black diamond	6.89	Fgh
Longa + boost extra	4.9	gh
Longa + zero application	3.11	h

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Grains and Stover Yield of Soybean (*Glycine max* [L.]Merrill) Varieties as Influence by Osmo--Priming in Gaya, Sudan Savanna of Nigeria

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ABSTRACT

Response of soybean varieties to osmo- priming duration were investigated under field condition at the Research Farm of the Faculty of Agriculture, Kano University of Science and Technology, Wudil, Gaya station in 2018 rainy season. The treatment consisted of four improved soybean varieties (TGX-1835, TGX-1904, TGX-1951 and TGX-1955) and four priming duration 0hour (dry seed or control), 4hours, 6hours and 8hours. These were combined and laid out in a randomized complete block design (RCBD) and replicated three times. The varieties tested differed significantly in the parameters investigated. The result showed that Soybean varieties TGX-1904 and TGX-1955 proved superior in terms of number of pods and seeds per plant, total grain yield and stover yield compared to the other varieties. In addition, priming duration has significant effect on both crop growth and yield parameters investigated. The highest value was obtained at 8 hour priming duration, where TGX-1904 and TGX-1951 recorded superior growth and yield parameters compared to TGX-1835 and TGX-1955. Therefore, from the foregoing, priming duration of 8 hours with varieties TGX-1904 and TGX-1955 is recommended for farmers in the area for good crop yield.

Keywords: Agro-ecology; Osmo-priming;**;** TGX-1955; Stover; Yield;

INTRODUCTION

Soybean (*Glycine max* [L.] Merr.) is one of the major legume crops in sub-Saharan Africa. The crop is beneficial in cereal cropping system because it contributes substantially to soil fertility. It is used to supplement cereals food stuff in many instances because cereals have low protein contents and are imbalanced in essential amino acid composition. Soybean protein has been the subject of intense investigation and has played an increasing role in human nutrition over the last few decades (Riaz, 2001). Nigeria is the largest producer of soybean in sub-Saharan Africa (SSA) but yield per unit area is usually low. According to FAO (2013), about six million tonnes of soybeans were produced in Nigeria in 2013, from 6 million hectares of land. Low productivity of the crop has been partly attributed to seed viability, poor germination and varietal differences. The use of high quality seed with appropriate seed rate is essential to establish a suitable plant population in a soybean field for better returns. Vigorous seeds germinate rapidly, uniformly and are able to withstand environmental adversity after sowing (Ajouri *et al*.,2015).

Osmo-priming or seed priming is a water based process that is carried out on seeds to increase uniformity of germination and emergence, and enhance plant establishment. Rapid germination and emergence of seed is an important factor of successful establishment. It is reported that seed priming is one of the most important developments to help rapid and uniform germination and emergence of seeds and to increase seed tolerance to adverse environmental conditions (Lewandowska *et al*., 2020). New varieties of soybean have been developed and released for cultivation NCRI, (2018). It is of interest to determine appropriate priming duration for these varieties with the aim of obtaining maximum yield of the crop and also increased economic value for the farmers in the study area. Therefore, this study determined the yield and yield components of soybean [*Glycine max* (L.) merrill] varieties as influenced by osmo-priming at Gaya, Kano State, Sudan Savanna Agro-ecological zone of Nigeria.

MATERIALS AND METHODS

Description of the experimental site

Field experiments was conducted during the 2018 rainy season at the Research Farm of the Faculty of Agriculture, Kano University of Science and Technology, Wudil, Gaya station (11^0. 14 and 738. 8038' with an altitude of 475 m above mean sea level. The average annual rainfall is about 700 mm. The pattern of rainfall in the area is highly variable. This can result in severe and widespread droughts that can impose serious socio-economic constraints (Tukur *et al*., 2013). The mean annual temperature ranges from 29 °C – 31 °C. The highest air temperature normally occurs in April/May and the lowest in December through February. Evapo-transpiration is generally high throughout the year. The vegetation of the area is the Sudan Savanna type which combines the characteristics and species of both the Guinea and Sahel Savanna (Tukur *et al*., 2013).

Treatments, Experimental Design

The treatments consists of four improved soybean varieties (TGX-1835, TGX-1904, TGX-1951 and TGX-1955) and 4 priming duration 0hour (dry seed or control), 4hours, 6hours and 8hours, these were combined in a 4 × 4 factorial experiment and laid out in a randomized complete block design (RCBD) and replicated three times. Samples of 5kg each of the soybean variety was placed in a container and soaked in tap water of pH 6.5 according to treatment specifications i.e (2hour intervals for 8 hours). The seeds were dried superficially afterwards.

Cultural Practices

The land was cleared and harrowed thoroughly to obtain fine tilth soil when the rain was fully established. Ridges were made at 0.75m apart using tractor mounted ridger. Each plot consisted of 6 ridges with 0.75cm apart, the size of each of the plot were 6 by 3m. Two seeds were initially sown per hole at 3cm soil depth and 5cm intra-row spacing and latter thinned to one plant per stand at two weeks after sowing. Single super phosphate (18% P_2O_5) was applied at the rate of 40kg P_2O_5 per hectare. The weeds were controlled manually using hoes 6 weeks after sowing (WAS). Careful observation of disease was considered although, no any serious threat was observed. When pods reached physiological maturity, harvesting was conducted immediately to avoid losses through shattering using cutlass. Threshing was conducted after sundrying for one week. The net plots were harvested as net plot for both grain and stover yield. Crop data such as plant stand count, number of plant stand, number of seeds per plant, grain and stover yield were collected from the plants within net plot (five plants were selected at random). Data collected on all measured parameters were subjected to Analysis of Variance (ANOVA) as described by Snedecor and Cohran (1967). Means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability (Duncan, 1955).

RESULTS

The effect of variety and priming duration on stand count of Soybean is shown in Table 1. At full emergence (7 days after sowing) result obtained showed significant impacts ($P < 0.05$) among the varieties tested with soybean variety TGX-1904 having significantly ($P < 0.05$) highest mean stand count TGX1904 (267) followed by TGX-1955 (214), whereas the least was obtained from TGX 1835 and TGX-1951 (101 and 84) which were similar. Priming duration at 0hour (control) gave significantly ($P < 0.05$) highest stand count of 249, this was followed by and 8hours (178). There was no significant interaction between the varieties and priming duration on stand count. Seed numbers per pod is a very important yield attribute to researchers, the performance of the varieties differed significantly among one another with TGX1904 significantly produced approximately 73 pods per plant. TGX-1955 and TGX1951 had 67 and 63 seeds respectively which were similar statistically. Among the priming duration evaluated on pod numbers per plant, their performance was the same. There were no significant effects among the varieties evaluated. The interaction between variety and priming duration on pod numbers per plant was not significant. Soybean grain yield ranged significantly ($p \leq 0.05$) from136.0 to 147.5 kg/ha. Significantly ($p \leq 0.05$) highest grain yield of 147.5 and 145.3 kg/ha was found in TGX-1955 and TG-X1904 respectively while the lowest grain yield (6136.0 kg/ha) was observed on TGX1951 among others. Among the priming duration evaluated, their performance was the same. There were no significant effects among the varieties evaluated. The interaction between variety and priming duration was not significant on grain yield. There were no significant impacts among the varieties investigated with respect to the stover yield; likewise the performance of the priming duration was the same. The interaction between variety and priming duration was not significant on the stover yield (Table 1).

Table 1: Effect of variety and seed priming duration on yield components of Soybean at Gaya during the 2018 rainy season

Treatment	Plant stand count	pods/ Plant	Grain yield (kg/ha)	Stover yield (kg/ha)
Variety (V)				
TGX-1835	101.00 c	54.400b	143.18ab	290.67
TGX1904	267.00 a	72.950a	145.33a	281.92
TGX1951	84.00c	63.000ab	136.00b	258.33
TGX-1955	214.00 b	67.350ab	147.50a	278.67
SE±	12.231	5.233	2.828	0.018
Priming Duration (PD)				
0 hour	249.00 a	68.500	140.58	254.50
4 hours	121.00 c	58.383	140.08	285.58
6 hours	117.00 c	69.433	141.67	290.00
8 hours	178.00 b	61.383	144.67	279.50
SE±	12.23	5.233	2.828	0.018
Interaction (V x PD)	NS	NS	NS	NS

Means followed by the same letters within a treatment group are not statistically different at 5% level of probability using DMRT. NS = Not Significant

DISCUSSION

Plant stand, number of pod per plant, grain and stover yield (t/ha) of the soybean varieties tested were significantly influenced by priming duration, however, priming duration with 8 hours exhibited more stand count and canopy height compared to others while the least priming duration of four hour was observe. This result agrees with the findings of Meseret (2020) which reports the speed of germination to increased as the priming duration increased from 0 hour to 14 hour and afterwards decreased rapidly with increasing priming duration with the least recorded in 24 hours. The relative increase in yield at 8 hours priming duration although not significant could be attributed to higher level of precipitation and better soil condition (moisture and soil nutrient) as earlier suggested by Zlatica *et al*. (2018). Significant increase in stand count was observed on variety TGX-1955 and TGX-1904 as compared to others, this may be attributed to the genetic factor which determined their growth habit. This result agreed with the findings of Shahram (2015) who reported that, higher number of stand count and plant height could be attained from the indeterminate varieties than the determinate types. Furthermore, soybean varieties TGX-1904 and TGX-1955 produced higher number of seeds per pod, grain and stover yield (t/ha). However, the interaction between the priming duration and the variety was not significant throughout the growth stages. These results confirm the findings of Michalak *et al*. (2018) who reported highest germination, improved emergence and good stand establishment in the field trials of pigeon pea primed seed, however, without any interaction found among the factors tested. Likewise Arif *et al*., (2005) reported improved and early germination as well as enhanced emergence in hydro primed seed but without any interaction amongst factors. There was no any significant interaction between the variety and priming duration for all the yield parameters.

Conclusion and Recommendations

The results of this study indicated significant effect of variety in some of the parameters on growth and yield measured. Also, it can be concluded that different hydro priming duration influenced the growth and yield on soybean varieties. These differences were also attributed to genetic variation among soybean varieties. From the foregoing, for good crop yield and food security, soybean varieties TGX-1904 and TGX-1951 with priming duration of 8 hours could be recommended for soybean farmers in the study area.

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Influence of organic and inorganic sources of nitrogen on the photosynthetic pigments concentration and performance of cucumber *(cucumis sativus)*

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ABSTRACT

Screen house experiment was conducted at the Landmark University Teaching and Research Farm Omu-aran Kwara State. The experiment was carried out to determine the influence of Organic and inorganic sources of N on the photosynthetic pigment concentration, and performance of Cucumber. Different rates of Urea at (0,60 and 120 t/ha) and Cow dung at (0,60 and 120 t/ha) were applied sole and combined. The experimental layout in the screen house was a completely randomized design (CRD) with three replicates respectively. Parameters were collected on the plant height, number of leaves, and number of branches, stem diameter, yield and photosynthetic pigments concentration. Data collected were subjected to Analysis of Variance (ANOVA) using GENSTAT Discovery Software, Edition 4. Comparison of the treatment means was carried out using the Duncan multiple rang test (DMRT) at 0.05 level of probability. The result of this study indicated that there was an increase in the vegetative parameters (vine length, stem girth, number of leaves and number of branches) of cucumber when applied with combined urea and cow dung as compared with sole application of the two amendments. The effect of application of $U_{60}CD_{60}$ was more pronounced on the performance, chlorophyll a, b, a+b and carotenoids of Cucumber. It can therefore be concluded that the combined application of urea and cow dung at $U_{60}CD_{60}$ is economical and suitable for the growth and increased photosynthetic pigments of cucumber.

Keywords: Cucmber, performance, pigments, organic and inorganic amendments

INTRODUCTION

Cucumber (*Cucumis sativus* var. sativus L.) is a member of the economically important family Cucurbitaceae which includes squash (Cucurbita ssp.), watermelon (*Citrullus lanatus)*, and melon (*Cucumis melo* L.). Cucumber and melon are grown more widely than any other vegetable species, next only to tomato (Solanum lycopersicum L) and watermelon (Pitrat *et al.* 1999).

Nitrogen is a very important element needed for plant growth as it gives plants the energy to grow and produce fruit or vegetables. Nitrogen is actually considered the most important component for supporting plant growth. Nitrogen is part of the chlorophyll molecule, which gives plants their green colour and is involved in creating food for the plant through photosynthesis (Home Guides, 2018). Lack of nitrogen shows up as general yellowing (chlorosis) of the plant. Because nitrogen is a highly mobile nutrient and as such moves around in the plant.

Some physiological parameters of plants include Chlorophyll a & b, Leaf Chlorophyll, Carotenoid, Xanthophyll amongst others**.** Chlorophyll and Carotenoid both make up to form photosynthetic pigment found in land plant (Kahn Academy, 2022)**.** A pigment is a generic term for a molecule that absorbs light and has a color**.** Chlorophyll and Carotenoid, are able to absorb the energy of light and use it effectively as a result of their molecular structure and organization within the cell of plant. Nitrogen is a major constituent of chlorophyll.

Light and nitrogen are two important factors that affect crop growth. Light is a prerequisite for photosynthesis and growth of plants. Nitrogen nutrition directly affects the photosynthetic rate and growth, and ultimately affects yield and light energy utilization. The objective of this study was to determine the performance, and photosynthetic pigments concentration of cucumber under the application of organic and inorganic sources of N fertilizer.

MATERIALS AND METHODS

Experimental Site:- Screen house experiment was conducted at the Teaching and Research Farm of Landmark University, Omu-Aran, Kwara State (Lat 8^o 9'N and Long 5^o 61'E) with an altitude of 495 meters' elevation above the sea level in the derived savannah zone of Nigeria with a predominant annual rainfall of about 600 mm – 1200 mm extending between April and September. The temperature of the study area varies between 33°C and 34°C during the year, with a distinct dry season from November to March.

Top soil was collected from the field around the screen house where no agricultural activities had been carried out for five years, the soil was thoroughly mixed using a hand trowel. Twenty (20) kg of the top soil was put inside the pot of size 30 x 17 cm, perforated at the bottom to allow for air and water movement.

Pre-cropping soil samples for the experiment was randomly taken and bulked to obtain composite samples for laboratory analysis. Organic manure (cow dung) was collected from the ranch of Landmark University farms located at the University Teaching and Research Farms. Urea fertilizer (46%) and cucumber seeds were purchased from a reputable agro-allied store in Omu-aran, Kwara state.

The cow dung used for the study was analyzed for its nutrient composition after being air-dried using warm air (18 – 21^oC) for 7 days. The dried cow dung was crushed and passed through a 2-

mm sieve. Analysis was done for Organic Carbon (OC), and the total concentration of N, P, K, Ca, Mg, Cu, Mn, Zn, and Na (AOAC, 2006). The variety of cucumber that was used for the experiment was the pionsett variety of Cucumber.

Treatments consisted of two sources of N fertilizer viz- Urea at 46% N (0, 60 and 120 kg N ha^{-1}) and cow dung (0, 60 and 120 t ha^{-1}). Treatments were combined and tested as follows: -U_0CD_0, U_0CD_{60}, U_0CD_{120}, $U_{60}CD_0$, $U_{60}CD_{60}$, $U_{60}CD_{120}$, $U_{120}CD_0$, $U_{120}CD_{60}$, and $U_{120}CD_{120}$. The treatments were arranged in the screen house according to a completely randomized design (CRD) using 30 cm by 60 cm inter- and intra-row spacing and was replicated three times.

Cow dung was applied two weeks before sowing for mineralization and nutrient release to take place while, urea fertilizer was applied two weeks after sowing. The equivalent of application of 0, 60 and 120 kg N ha^{-1} of urea to 20 kg of soil were 0 g, 1.3 g, and 2.6 g while the equivalent of the application 0, 60, and 120 kg N cow dung to 20 kg of soil were 0 g, 33.33 g, and 66.67 g.
Two cucumber seeds were sown per pot at a depth of about 5 cm. At two weeks after sowing, thinning operation was carried out leaving one vigorous and healthy seedling per pot. Regular irrigation with a small quantity of water was applied during the first one week after sowing using the drip irrigation system, subsequent deep irrigation and one to two days' water stress was adopted to encourage deep rooting.
Training and trellising were carried out on a weekly basis and as the need arises. Training helps the plants to grow vertically while trellising supports the plant to grow horizontally.
Mature fruits were harvested at intervals of five days for four weeks before the experiment was terminated. Harvested fruits were weighed with the aid of automated weighing balance of maximum capacity of 2100 g, readable at 0.01 g, and a model by OHAUS Corporation, USA. Fruit sample of each treatment was thereafter taken to the laboratory for chlorophyll and carotenoid determination.
The following parameters were monitored during the experiment- Vine length (cm), number of leaves, number of primary branches, stem diameter (cm), number of days to first flowering, number of days to 50% flowering, Fruit weight and determination of leaf photosynthetic pigments (chlorophyll a, b, a+b, and β-Carotenoid).

Statistical Analysis
Data obtained from the study were subjected to statistical analysis of variance (ANOVA) using GENSTAT discovery (2014). A Comparison of the treatment means for significance was carried out using the Duncan multiple range test (DMRT) at 5% level of probability.

RESULTS

Initial Soil Properties: - The pre-planting soil analysis is as shown in Table 1. The pH of the soil was strongly acidic, the Nitrogen content of the soil was very low, the available phosphorus was high, and the exchangeable K was also low while the exchangeable Na, Ca and Mg were all suitable. The organic matter was low. The soil is high in sand with relatively low values in both silt and clay; hence the textural class is Sandy Loam.

Table 1: Pre-cropping soil physicochemical analysis

Property	Value
Sand (%)	69.2
Silt (%)	14.5
Clay (%)	16.3
Soil texture	Sandy loam
PH (water)	5.62
Organic matter (%)	1.88
Total N (%)	0.15
Available P (mg kg-1)	9.71
Exchangeable K (cmol kg-1)	0.14
Exchangeable Ca (cmol kg-1)	2.45
Exchangeable Mg (cmol kg-1)	0.34

Chemical Composition of the cow dung used for the study

The results of the laboratory analyses of the cow dung used for the study is shown in Table 2. The results showed that cow dung contained varying values of macro and micro-nutrients required for improved soil fertility and plant growth.

Table 2. Chemical composition of the organic amendments (Cow Dung) used for the study

Parameters	O.C%	N%	P%	K%	Ca%	Mg%	Zn%	C:N
Values	25.70	1.84	0.82	1.98	0.99	0.54	0.10	14.78

Effects of the application of urea and cow dung on vine length and number of leaves of cucumber

The sole and different combinations of the application of cow dung and urea showed a significant effect on the vine length and stem girth of cucumber. The vine length of cucumber significantly increased with the application of sole cow dung, urea and their combinations (Table 3). Though the difference in vine length with the application of amendments was not significant at 2 WAS and at 4 WAS when $U_{60}CD_{60}$, $U_{60}CD_{120}$, $U_{120}CD_{0}$, $U_{120}CD_{60}$ and $U_{120}CD_{120}$ were applied. At 6 and 8 WAS all treatments with combined cow dung and urea significantly increased the vine length. The control gave the least value for vine length.

The data revealed a non-significant effect of amendments on number of leaves at 4 and 6 WAS. Compared with the control which gave the least number of leaves, a significant maximum number of leaves was observed in plots applied with $U_{120}CD_{60}$ at 6 and 8 WAS, though the value was statistically similar to the values obtained when $U_{60}CD_{60}$, $U_{60}CD_{120}$, $U_{120}CD_{0}$, and $U_{120}CD_{120}$ were applied.

Table 3: Effect of the application of urea and cow dung on vine length and stem diameter of cucumber.

Treatment	Vine Length (cm)					Number of Leaves		
	2 WAS	2 WAS	4 WAS	6 WAS	8 WAS	4 WAS	6 WAS	8 WAS
U_0CD_0	5.167b	1.667a	3.000b	11.33c	17.33c	14.67c	79.00d	105.33d
U_0CD_{60}	6.167ab	2.000a	4.667ab	16.33b	22.67b	17.67bc	93.72c	135.32c
U_0CD_{120}	6.000ab	1.667a	4.333ab	17.00c	24.67b	18.83bc	96.20c	130.45c
$U_{60}CD_0$	6.833ab	2.333a	4.667ab	17.67b	23.67b	20.52b	107.71b	160.34b
$U_{60}CD_{60}$	6.833ab	2.000a	5.000a	22.33a	34.00a	29.50a	144.29a	199.52a
$U_{60}CD_{120}$	6.833ab	2.000a	5.333a	22.00a	34.33a	30.33a	147.70a	200.57a
$U_{120}CD_0$	7.167ab	1.667a	4.333ab	21.67ab	32.00a	29.72a	130.62b	167.44b
$U_{120}CD_{60}$	8.333a	2.333a	5.667a	23.67a	35.67a	30.67a	145.33a	202.85a
$U_{120}CD_{120}$	7.500ab	1.667a	5.333a	23.67a	33.67a	32.50a	147.70a	200.10a

Means followed by the same letter(s) are not significantly different from each other at 5% level of probability.

Effects of the application of urea and cow dung on the number of days to first flowering, the number of days to maturity and fruit weight of cucumber.

Table 4 presents the effects of urea and cow dung on the phenology, number of days to maturity, and fruit weight. Data presented showed that pots applied with $U_{120}CD_{120}$ produced first flower earlier than the other treatments and were statistically similar to pots applied with $U_{60}CD_{60}$, $U_{60}CD_{120}$, $U_{120}CD_{0}$, $U_{120}CD_{60}$, and $U_{120}CD_{120}$. In a similar vein, control pots had a delayed number of days to 50% flowering followed by pots amended with U_0CD_{60}, U_0CD_{120}, and $U_{60}CD_0$. Pots amended with $U_{120}CD_{120}$ had a delayed number of days to 50% flowering though statistically similar to the application of $U_{60}CD_{60}$, $U_{60}CD_{120}$, $U_{120}CD_{0}$, and $U_{120}CD_{60}$.

The effect of treatments on the number of days to maturity shows that cucumber fruits matured earlier with the application of $U_{60}CD_{60}$, and $U_{60}CD_{120}$. Other treatments produced a significant and similar number of days to fruit maturity. Non-significant heavier fruit weight was observed with pots treated with combined application of urea and cow dung..

Table 4: Effect of the application of urea and cow dung on flower pattern, fruit maturity and fruit weight of cucumber of cucumber.

Treatment	Days to First Flowering	Days to 50% Flowering	Days to Fruit Maturity	Fruit Weight
U_0CD_0	44.67a	53.33a	0.00c	0.000c

U_0CD_{60}	43.00a	48.00b	51.67a	0.242b
U_0CD_{120}	43.67a	49.33b	51.67a	0.248b
$U_{60}CD_0$	43.67a	49.00b	51.00a	0.233b
$U_{60}CD_{60}$	40.67b	45.00c	48.33b	0.335a
$U_{60}CD_{120}$	40.00b	46.67c	49.33b	0.342a
$U_{120}CD_0$	40.00b	46.67c	53.67a	0.237b
$U_{120}CD_{60}$	39.33b	43.33c	51.33a	0.333a
$U_{120}CD_{120}$	38.33b	42.33c	51.00a	0.323a

Means followed by the same letter(s) are not significantly different from each other at 5% level of probability.

Effects of the application of urea and cow dung on leaf chlorophyll a, b, a+b, and β-carotenoids of cucumber

The leaf photosynthetic parameters are as shown in Table 5. Treated cucumber with combined application of urea and cow dung significantly increased all the photosynthetic pigments. The leaf chlorophyll a, b, a+b, and β-carotenoids were higher with the application of $U_{60}CD_{120}$ and $U_{120}CD_{60}$ though the values were not significantly different from the values obtained $U_{60}CD_{60}$, $U_{120}CD_{60}$, and $U_{120}CD_{120}$. The control treatment significantly reduced values for all the photosynthetic pigments except chlorophyll b where the value was statistically similar with the values obtained when U_0CD_{60}, U_0CD_{120}, and $U_{60}CD_0$ were applied.

Table 5: Effect of the application of urea and cow dung on leaf chlorophyll a, b, a+b, and β-carotenoids of cucumber

Treatment	Leaf Chlorophyll (a)	Leaf Chlorophyll (b)	Leaf Chlorophyll (a+b)	Leaf Carotenoid (β)
U_0CD_0	0.207c	0.193b	0.457c	0.174c
U_0CD_{60}	0.400b	0.267b	0.620b	0.28b
U_0CD_{120}	0.443b	0.203b	0.653b	0.26b
$U_{60}CD_0$	0.447b	0.243b	0.590b	0.29b
$U_{60}CD_{60}$	0.676a	0.347a	0.933a	0.49a
$U_{60}CD_{120}$	0.687a	0.383a	1.2000a	0.60a
$U_{120}CD_0$	0.643a	0.340a	0.950a	0.49a
$U_{120}CD_{60}$	0.697a	0.383a	0.999a	0.59a
$U_{120}CD_{120}$	0.685a	0.313a	0.950a	0.47a

Means followed by the same letter(s) are not significantly different from each other at 5% level of probability.

DISCUSSION

Nitrogen (N) is one of the most important nutrients affecting the growth, development, yield and fruit quality of plants (Gerenda´ s *et al.*, 1997). Adequate supply of N to crops is fundamental to optimize crop yields, but an excessive N application can result in contamination of groundwater (Jaynes *et al*., 2001). The result of this study indicated that there was an increase in the vegetative parameters of cucumber when applied with combined urea and cow dung as compared with sole application of the two amendments. The difference in the vegetative parameters could be as a result of the combined effect of urea and cow dung.

The combined application of the two sources of N used for the study had greater effect on the yield of cucumber. The significant increase in yield and its attributes could be adduced to the continuous supply of nutrients to the crop as a result of the use of organic source of N which assisted the crop in the uptake and utilization of nutrients. Organic manure has been reported to improve plant nutrient uptake by acting as a buffering agent against undesirable pH fluctuations and by improving soil water availability through retention and aeration which ultimately contributes to better nutrients utilization by the crop (Adediran *et al.* 2015).

Photosynthetic pigment content plays a critical role in photosynthesis. Chlorophyll is important for energy capture during the photosynthesis process. Differences in chlorophyll activity could be considered as a current symptom of inappropriate fertilization, or due to a nutritional imbalance, however other environmental factors, such as temperature, salinity, or drought can also decrease chlorophyll activity (Zekri, 1991).

The study revealed that there were significant effects of different sources of N on the photosynthetic pigments of cucumber. Increased N supply stimulates plant growth and productivity, as well as photosynthetic capacity of leaves through increased amounts of stromal and thylakoid proteins in leaves (Teixeira Filho et al., 2011)

Application of urea and cow dung had significant effect on leaf chlorophyll a, chlorophyll b, total (a+b) and carotenoides. The higher values of chlorophyll a, b (a+b) and carotenides were obtained on plots fertilized with combined application of the two amendments and high rate of sole application of urea ($U_{120}CD_0$). Increased in these pigments as a result of the application of the two sources of N could be because nitrogen is a constituent molecule of chlorophyll. It could also be as a result of nitrogen being the main constituent of all amino acids and hence of proteins and lipids as glactolipids, acting as a structural components of chloroplast. The result of this study is in agreement with those obtained by El-Robae (2002) who found that concentration of chlorophyll a, b, total (a+b) and carotenoids in leaf tissues of tomato increased with increasing N. Increase in chlorophyll a, b and a+b of the leaves and fruit of cucumber as a result of application of combined organic and inorganic sources of N could also be as a result of the effects of the organic N which releases its nutrients gradually. This is in agreement with the works of Abd Alla et al. (2009) who found that, cucumber treated with a biofertilizer produced higher chlorophyll content in its leaves.

CONCLUSION

The combined application of urea and cow dung at varying levels significantly increased all the parameters measured. This study clearly showed that increased photosynthetic pigments are related to the increasing levels of N amendments. The effect of application of $U_{60}CD_{60}$ was more pronounced on the performance of cucumber chlorophyll a, b, a+b concentration and carotenoids. Based on these findings, it is recommended that the combined application of urea and cow dung at the rate of $U_{60}CD_{60}$ is economical and suitable for the growth and increased photosynthetic pigments of cucumber.

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Effects of different types of organic fertilizers on the growth, yield and quality of five genotypes of tomato grown under screen house condition

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ABSTRACT

It is important to select appropriate cultivars that are well adapted and suited to specific ecological zones and also transform agricultural waste into useful and rich sources of organic nutrient. Hence, study was conducted to determine the effect of different types of organic fertilizer on the growth, yield and quality of five genotypes of tomato grown under screen house condition. The experiment was a two-factor experiment comprising of five tomato genotypes (NGBOO722, NGB00724, NGB00692, NGB00714 and OMU-ARAN LOCAL), two organic fertilizers treatment (cocoa pod and fluted pumpkin pod) and a control (no fertilizer of any kind). The experiment was laid out in Completely Randomized Design (CRD) and each treatment was replicated three times. The results of this study revealed that organic fertilizers produced from Cocoa and fluted pumpkin pods increased the growth, yield and mineral contents of tomato relative to the control and fluted pumpkin pod fertilizer increased these parameters relative to cocoa pod fertilizer due to its high nutrient contents. Among tomato genotypes, NGB00714 produced the highest plant height, stem girth and number of branches, the value was statistically similar to NGB00722, NGB00724 and NGB00692, whereas OMU-ARAN LOCAL had the least value. The order of fruit yield were: NGB00714 > NGB00722 > NGB00724 > NGB00629 > Omu-Aran Local. The yield of tomato genotype NGB00714 amongst the tested cultivars was significantly higher than that of other cultivars and are therefore recommended to farmers wishing to key into tomato production in the area.

Keywords: Tomato genotype; cocoa pod fertilizer; fluted pumpkin pods fertilizer;

INTRODUCTION

Tomato *(Solanum lycopersicum*) is one of the most important edible and highly nutritious vegetable crops, it is a very important vegetable in the world. Tomatoes are also high in minerals, vitamins, essential amino acids, sugars, and dietary fibers, which contribute to a stable, well-balanced diet. Tomatoes are high in vitamin B and C, as well as iron and phosphorus. Tomatoes can be eaten raw in salads or baked in sauces, soups, and meat and fish dishes. Purées, juices, and ketchup can all be made from them. Tomatoes, both canned and dry, are environmentally friendly.

The fertilization system is one of the most important factors that influence crop quality in food production especially in crop like tomato (Ogbonna, 2008). Since soil fertility is one of the most important factors, it is therefore of necessity to add fertilizer to the soil to boost its fertility. Lack of sufficient amounts of nutrients result in poor performance of the crop with growth been affected resulting to low yield (Adekiya et al., 2020) .Organic fertilizers, in this case used (cocoa pod and fluted pumpkin pod) are agricultural wastes which were converted to fertilizers. They play a critical role in both short-term nutrient availability and longer-term maintenance of soil organic matter in smaller holder farming systems in the tropics. The use of organic fertilizer now become important and necessary due to recent trend toward consumption of organically produced vegetables in contracts to in-organic grown vegetables which is said to be detrimental to human health.

Also there is need to transform agricultural waste into useful and rich sources of organic nutrient with respect to the SDGs 12 this is to ensure the culture of recycling and reusing agricultural waste products, the nutrient content of cocoa pod is high. There is need to keep up with the trend that explains the consumption of organically produce vegetables which do not have health implications compared to the consumption of vegetables cultivated with organic fertilizers which is in line with the SDG 3 (good health and wellbeing). Hence there is need to reduce the use of inorganic fertilizers which causes environmental degradation, pollution, emission of greenhouse gas etc. and increase the use of organic fertilizers.

Furthermore, the various varieties of tomato could respond to organic fertilizer differently. It is important to select appropriate cultivars that are well adapted and suited to specific ecological zones in order to ensure optimum growth and efficient performance. The choice of varieties needs to be selected based on the combination of yield, flavor, texture, appearance of fruits. Therefore main objectives of the study were to determine the effect of different types of organic fertilizer on the growth, yield and quality of five genotypes of tomato grown under screen house condition

MATERIALS AND METHODS

Description of the experimental site, soil collection and source of planting materials

The experiment was conducted at the Screen House of the Teaching and Research Farms of Landmark University Omu-Aran, Kwara state (Latitude 8° 9′N and Longitude 5° 61′E) located at the derived savannah zone of Nigeria. The experiment was carried out in a screen house that had a galvanized iron as a frame, a UV covering on top, side net for screening insect pests with the floor fairly covered with granite. Temperature and relative humidity within the screen house during the period of the experiment was monitored using a Thermograph and a Barograph and they were at an average of 31°C and 75%, respectively. The soil at Omu-Aran is an Oxic Haplustalf from the USDA soil order Alfisol or Luvisol from the FAO soil classification. Soil samples were taken from an area that has been exposed to maize cultivation for two years. Top soil was collected from the Farm field through excavation using shovel and digger which was then transported to the weighing and bagging site using a wheel barrow, soil was thoroughly mixed, sieved and bagged at 13 kg in a polythene bag of 30cm × 17cm which was also perforated to allow aeration and water drainage.

Five genotypes of tomato seed were collected from NACGRAB in Ibadan Nigeria where were (NGBOO722, NGB00724, NGB00692, NGB00714 and OMU-ARAN LOCAL sourced from Omu-Aran market.

Experimental design, treatment and tomato nursery and transplanting

The experiment was a two-factor experiment comprising of five tomato genotypes (NGBOO722, NGB00724, NGB00692, NGB00714 and OMU-ARAN LOCAL), two organic fertilizers treatment (cocoa pod and fluted pumpkin pod) and a control (no fertilizer of any kind). The experiment was laid out in Completely Randomized Design (CRD) and each treatment was replicated three times. Cocoa pod fertilizer was applied at 13 g per 13 kg of soil and fluted pumpkin pod fertilizer at 12g per 13 kg of soil. The application of organic fertilizer differ in weight due to the content of Nitrogen element present in the two organic fertilizer, the cocoa pod fertilizer has a lower Nitrogen element when compared to the fluted pumpkin pod fertilizer. Prior to filling of bags with soil, seeds of the five genotypes of tomato were sown into a rich loamy soil in some portion of the screen house and watered daily in the evening using a watering can to field capacity. After 3 weeks in the nursery the seedlings were transplanted to the already prepared and watered soil in the bag. Two tomato seedling were transplanted per bag which was later thinned to one per bag.

Laboratory Analysis of pre-planting soil and Tomato Fruit

Soil physical and chemical analyses were performed on the 2 mm sieved initial samples before transplanting of tomato using methods as described by Carter (1993).

Tomato fruits were collected from each treatment, oven dried for 24 h at 80^{o}C and these samples were analysed for N, P, K, Ca and Mg as described by Tel and Hagarty (1984) and vitamin C content was determined by using the indophenol dye method (Singh et al., 2007)

Growth and yield parameters

Plant height: - The height of each plant per pot was measured at 1, 2, 3 and 4 weeks after transplanting (WAT) using a meter rule, number of leaves by counting the number of fully expanded leaves. The stem girth was taken at 1, 2, 3 and 4 WAT. Tomato fruits was harvested at maturity and the number of harvested fruits were recorded per bag and per treatment. Harvested matured tomato fruits were weighed using a sensitive weighing balance and the value were recorded.

3.8 Data Analysis

Data collected was subjected to statistical analysis of variance (ANOVA) using Statistical Analysis Software (SAS, Institute Inc. 2000). The treatment means were compared using the Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

RESULTS

Initial Soil Properties and Analysis of Organic fertilizer used

The pre-planting soil analysis contains 69.2%, 14.5%, and 16.3% of sand silt and clay respectively, and 5.62, 1.88%, 0.15mg kg^{-1}, 0.14 cmol kg^{-1}, 2.45cmolkg^{-1} and 0.34 cmol kg^{-1} respectively for pH, OM, N, P, K, Ca and Mg. The nutrient content of the soil was generally low. The chemical analysis of the organic fertilizers used for the experiment is presented in Table 1. The fertilizers are rich in macro (N (7.74% for cocoa pod and 8.46% for pumpkin pod), P (0.80% for cocoa pod and 0.44 for pumpkin pod), and K (1.19% for both cocoa and pumpkin pods)) and micro nutrients (Cu, Fe, Mn, Zn) that can add substantial nutrients to the degraded soil and hence improve the growth, yield and qualities of the tomatoes.

Table 1: Chemical composition of the organic fertilizers used for the cultivation of tomat0 genotypes

Property	Cocoa pod	Fluted pumpkin pod
pH (water)	7.35	7.35
Copper (%)	0.56	0.67
Calcium (%)	11.20	13.20
Iron (%)	0.16	0.18
Magnesium (%)	3.44	5.24
Manganese (%)	0.003	0.004
Potassium (%)	1.05	1.19
Nitrogen (%)	7.74	8.46
Phosphorus (%)	0.40	0.84
Zinc (%)	3.60	2.38

Effects of fertilizer and genotype on growth and yield of tomato

Table 2 shows the result of the effects of fertilizer and genotypes on the growth and yield of tomato Fertilizer and genotype significantly ($p = 0.05$) influenced the on growth and yield of tomato. Using fertilizer as a single factor, pumpkin pod increased the on growth (plant height, stem girth, number of branches and number of leaves) and yield (number of fruits and fruit weight) of tomato of tomato relative to cocoa pod and the control. The control had the least values. Using genotype as a single factor, NGB00714 produced the highest plant height, stem girth and number of branches, the value was statistically similar to NGB00722, NGB00724 and NGB00692, whereas

OMU-ARAN LOCAL had the least value. The order of fruit yield were: NGB00714 > NGB00722 > NGB00724 > NGB00629 > Omu-Aran Local. The interactive effect of fertilizer and Genotype (F × G) was not significant for any growth and yield parameters.

	Plant height (cm)	Stem girth (cm)	Number of branches	Number of leaves	Number of fruits	Fruit weight (g)
Fertilizer						
Control	34.19c	2.51b	4.49b	9.58c	4.13c	38.40c
Cocoa pod fertilizer	44.29b	3.16a	5.89a	11.48ab	8.46b	103.56b
Fluted pumpkin pod fertilizer	47.57a	3.18a	5.89a	12.05a	9.26a	133.56a
Genotype						
NGB00722	66.00a	4.11a	9.33a	16.22b	10.00ab	120.12b
NGB00724	62.44a	3.72a	8.33a	14.22b	4.66bc	85.66c
NGB00692	59.22a	3.88a	7.00ab	12.77bc	7.22abc	76.17d
NGB00714	72.66a	4.05a	9.00ab	19.77a	11.77a	128.54a
OMU-ARAN LOCAL	37.77b	2.88c	6.77c	10.22c	2.77c	48.71e
Fertilizer (F)	0.014	0.021	0.000	0.006	0.008	0.008
Genotype (G)	0.001	0.022	0.045	0.000	0.041	0.04
F × G	0.309	0.198	0.538	0.135	0.255	0.104

Values followed by similar letters under the same column are not significantly different at p = 0.05 according to Duncan's multiple range test

Effects of fertilizer and genotype on Mineral composition of tomato

Table 8 shows the effect of fertilizer and genotype on mineral composition of tomato genotypes. Fertilizer and genotype significantly (p = 0.05) influence the magnesium, calcium, potassium and nitrogen composition of tomato. Pumpkin pod had highest magnesium, potassium, calcium and nitrogen composition. Using genotype as a single factor, NGB00722 recorded highest value for magnesium and potassium composition, NGB00692 recorded highest value for calcium composition while NGB00714 recorded highest value for nitrogen. The interactive effect of fertilizer and Genotype (F × G) was significant on mineral composition of tomato.

Table 8: Effects of fertilizer and genotype on Mineral composition of tomato

Treatments	Mg	Ca	K	N
Fertilizer				
Control	1.27c	1.34c	0.14c	0.12c
Cocoa pod fertilizer	1.65b	1.67b	0.16b	0.19b
Fluted pumpkin pod fertilizer	1.83a	1.84a	0.20a	0.21a
Genotype				
NGB00722	2.19a	1.52c	0.23a	0.19b
NGB00724	2.05b	1.59b	0.19b	0.13e
NGB00692	0.70e	1.99a	0.12d	0.19c
NGB00714	1.05d	1.45e	0.14c	0.28a
OMU-ARAN LOCAL	1.93c	1.50c	0.14c	0.17d
Fertilizer (F)	0.000	0.000	0.000	0.000
Genotype (G)	0.000	0.000	0.000	0.000
F × G	0.000	0.000	0.000	0.000

Values followed by similar letters under the same column are not significantly different at p = 0.05 according to Duncan's multiple range test

DISCUSSION

Fertilizer treatments increasing the growth and yield of tomato relative to the control showed that the fertilizers are rich in nutrients and affirmed that these nutrients in the fertilizers are released into the soil for plant uptake. It also suggests that the soil used for the experiment was deficient in nutrients.

Pumpkin pod fertilizer enhanced higher vegetative growth and yield than the cocoa pod fertilizer as a result of higher nitrogen composition in the fluted pumpkin fertilizer treatment (Table 2).The pumpkin fertilizer applied would have increased N supply to the soil and consequently absorbed by the tomato plant and hence increased number of leaves and photosynthetic activity and enhancing physiological processes leading to the production of more assimilates which leads to increase in chemical composition of the tomato leaves hence higher yield (Adekiya et al., 2019).

Increasing the Nitrogen content of treatments will increase vegetative parameters of tomato genotypes due to this mechanism; increase in nitrogen uptake will result to increase in synthesis and accumulation of amino acids in the plant (Atanasova, 2008), increasing the chlorophyll content of green plant and promoting growth of cells and tissues (Atanasova, 2008).

The significant difference in plant growth and yield of tomato due to the different genotypes particularly with NGB00714 having the best values could be attributed to their distinct growth habit and genetic difference in the five genotypes which put NGB00714 to be the best and OMU-ARAN LOCAL the least as well as their adaptability to the soil under study as well as the soil nutrient content.

The fact that organic fertilizer treatments increased tomato mineral contents compared with the control was attributed to increased availability of the nutrients in soil as a result of the mineralization of the organic fertilizers leading to increased uptake by tomato plants. Fluted pumpkin pod fertilizer had the highest values of N, K, Ca and Mg in the tomato fruit compared with cocoa pod fertilizer, this was attributed to the superior nutrient contents of fluted pumpkin pod fertilizer relative with cocoa pod fertilizer

CONCLUSION

The results of this study revealed that organic fertilizers produced from Cocoa and fluted pumpkin pods increased the growth, yield and mineral contents of tomato relative to the control and fluted pumpkin pod fertilizer increased these parameters relative to cocoa pod fertilizer due to its high nutrient contents.

Among tomato genotypes, NGB00714 produced the highest plant height, stem girth and number of branches, the value was statistically similar to NGB00722, NGB00724 and NGB00692, whereas OMU-ARAN LOCAL had the least value. The order of fruit yield were: NGB00714 > NGB00722 > NGB00724 > NGB00629 > Omu-Aran Local. The yield of tomato genotype NGB00714 amongst the tested cultivars was significantly higher than that of other cultivars and are therefore recommended to farmers wishing to key into tomato production in the area.

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Effects of Seedbed, Cover Crop And Density On Weed Control And Cassava Root Yield In A Yam/Cassava/Maize Intercrop In Ishiagu Ebonyi State.

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ABSTRACT

A field experiment was carried out at the Teaching and Research Farm of the Federal College of Agriculture Ishiagu- Ebonyi state during the 2014 and 2015 planting seasons. Ishiagu is within the southern part of Ebonyi state and lies on Latitude 5^0 57^1N and on Longitude 7^0 34^1E with a mean annual rainfall of 1350mm with an average humidity of 88% and a mean annual temperature of 29^0C (FCAI, 2009). It has gentle slope topography. The main objective was to determine the effect of seedbed, cover crop species and densities on the weed control and yield of cassava in yam/cassava/maize intercrop. It was a split -split plot experiment fitted into randomized complete block design and replicated three times. The main plot was seedbed consisting of ridge and flat, the sub plots were cover crop species of egusi melon, pumpkin and sweet potato, the sub-sub plots were cover crops densities of 0, 10,000, 20,000 and 30,000 plants/ha. Data was collected on the fresh cassava root yield. Data were subjected to statistical analysis of variance.(ANOVA) using Genstat® version 3.0 (2003) software packages and significant means were separated using least significant difference (LSD) at 5% probability level. The yields of the fresh cassava roots were significantly improved by the seedbed type. The ridge had more root yield than the flat. The cover crop species significantly affected the root yield as the pumpkin plots had higher root yield than sweet potato and the egusi melon plots. Density reduced the yield of the roots though there was an increase at 30,000 stands /ha

Key words: Seedbed, Cover crop species, Density, Intercrop, Yield, Ishiagu

INTRODUCTION

Intercropping is the practice of growing two or more crops simultaneously in close proximity in a definite pattern, alternate rows or set of rows within the same plot (Reddy, 2012). Intercropping encourages intensification of crop production in both time and space dimensions. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources or ecological processes that would otherwise not be utilized by a single crop (Ouma, 2010). Yield advantage in intercropping occurs due to the component crops differences in the use of growth resources. When they are grown in combination, they are able to complement each other and do make better use of overall resources than when they are grown separately (Reddy,2012). In dry land agriculture intercropping is practiced mainly to minimize the risk of total crop failure due to rainfall vagaries rather than yield and economic advantage over sole cropping, as tropical weather is very unpredictable as rain fall and drought occur spontaneously (Bello *et al*, 2013). Rainfall is heavy and soil depletion and leaching are eminent, intercropping acts as an insurance against failure of crops in abnormal year (Agris info.in, 2005). The advantages of intercropping include greater system resilience by the interplay of different crops, greater crop production (Ghaffarzadeh *et al*, 1997), reduced disease transfer and environmental benefits such as greater soil and water conservation (Gilley *et al*, 2002). These advantages occur because the component crops differ in their use of growth resources (Reddy, 2012). Intercropping of compatible plants encourages biodiversity, by providing a habitat for different insects and soil organisms that would not be present in a single crop environment (Altieri and Nicholls, 2004).

Such concern has necessitated interest in finding systems that minimizes negative impact on the soil while maintaining sustainable crop production. This is true especially with cover crops or smother crops such as forage legumes inter seeded with a main crop such as cereals. This experiment therefore was designed to determine the effects of seedbed practices, cover crops and density on the yield of fresh cassava roots in a yam/cassava/maize intercrop

MATERIALS AND METHODS

This experiment was conducted at the Teaching and Research Farm of the Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria during the 2014/ 2015 planting seasons. Ishiagu is a tropical environment and lies on Latitude 5^0 57^1N and longitude 7^0 34^1E with an annual rainfall of 1350mm, it has an average humidity of 88% and a mean annual temperature of 29^0C (Nwite *et al*, 2008) and is situated on a gentle slope. The experiment was a split- split plot experiment, fitted into a Randomized Complete Block Design (RCBD) and replicated three times. Two seedbed practices were adopted, conventional seedbed (ridge) and harrowed seedbed (flat). In conventional seedbed, the bush was cleared by slashing and the plot ploughed, after two weeks it was harrowed and ridged. On harrowed seedbed the plot was cleared by slashing, ploughed and after two weeks it was harrowed and marked out. Three cover crop species were used Egusi-melon *Citrullus vulgaris*, pumpkin *Cucurbita moschata* and sweet potato *Ipomea batatas*. The cover crops were planted at different densities, ten thousand, twenty thousand, thirty thousand and control (zero) stands per hectare (10,000, 20,000, 30,000 and 0 stands/ha)

Planting of Test Crops, Yam. Setts of 100g of yam (*Dioscorea rotundata* L) cultivar 'agboghohu' were measured out using Ohaus sensitive scale. The yam setts were planted on the crest of the ridges and on the flats, according to the treatment schedule at a distance of 1m x 1m within row and 1m between rows at a population density of 10,000 plants /ha.

Cassava. Cassava (*Manihot esculenta*, Crantz) stem cuttings of 30 cm, variety TMS 0581 were planted on mid way down the ridge on the right side of the yam at a distance of 1m x 1m and also on flat by the right side of yam stands at a population density of 10,000 plants /ha.

Maize. The maize (*Zea mays* L) variety 'Oba super11' seeds were planted. Planting was at the foot of the ridges and flats, opposite the cassava stands, 1m within row and 1m between rows.

Three seeds were planted per hole at a depth of 4cm and thinned to one stand at two weeks after planting (2WAP) which gave a population of 10,000 plants / ha.

Cover crops. Melon: *Citrullus vulgaris* (Schrad), ('egusi' melon) and **Pumpkin:** *Cucurbita moschata* (L.) 'Anyu' seeds were planted, 4 seeds per hole and at a depth of 4cm. The seeds were planted on the mid way on the ridges and flats at the same side with maize and in holes opposite the cassava stands at a distance of 1m x 1m. The seedlings were thinned to respective densities of 10,000, 20,000 and 30,000 plants/ha after two weeks of planting (2 WAP), while there was none planted on the control. **Sweet potato**: *Ipomoea batatas* (L.) Lam. Vines of variety TIS 2498, spreading type obtained from National Root Crops Research Institute Umudike were planted on the mid way on ridges and flats. Sweet potato vine cuttings of 25cm length with four nodes were planted at angle of 45^0 on the same side with maize opposite the cassava stands. This was done at a spacing of 1m x 1m for 10,000 plants/ha (15 stands), 0.5m x1m for 20,000 plants/ha (30 stands) and 33.3cm x 1m for 30,000 plants /ha (45stands) while none was planted on the control. (0).

Yield. The cassava roots were harvested at 32WAP and the yield was measured in tonnes per hectare (t/ha). Yield = Average yield of the tagged plants multiplied by the crop planting density.

Analysis of Data. The data collected on fresh cassava roots yield and subjected to statistical analysis (ANOVA) using Gensat3 statistical software. Significant means were separated using LSD at P= 0.05 as described by Wahua (2010)

RESULTS AND DISCUSSIONS

Yield of fresh cassava roots

Seedbed type significantly increased the cassava root yield. Ridge produced significantly higher fresh cassava root yield than the flat (Table 3) Pumpkin cover crop produced the highest cassava roots followed by sweet potato while egusi melon produced the least. This may be due to its high leaf area which was used to cover the soil and maintained reduced soil moisture loss or the production of root exudates which had allelopathic effects on weeds and controlled soil diseases. This is in agreement with Kruidhof, *et al* (2008) who found out that some cover crops can prevent the development of weeds population, control soil diseases, increase organic matter and reduce soil losses. Density of cover crops decreased the yield of the cassava roots as the control had the highest cassava roots yield. The control (No cover crop plots) where plots were manually weeded benefited cassava roots yield over other cover crop densities.

CONCLUSION

The use of ridge in cassava production was more rewarding as the yield in tonnes / hectare of fresh cassava roots was more than on flat. Cassava planted in ridges increase the cassava root yield as the roots penetrate deep into the soil allowing roots growth and expansion. The cover crops ensured reduced effect of torrential rains on the soil avoiding erosion and runoffs. The results were obtained based on the prevailing situation at the time of the experiment.

Table 1: Effect of Seedbed, cover crop and density on cassava root yield means (t/ha) in 2014/2015

Tillage	Cover crop sp	Density /ha					Cover crop means
		No cover crop	10, 000	20, 000	30, 000	Means	
Flat	Egusi melon	26.16	20.33	15.33	14.83	19.16	
	Pumpkin	23.33	18.66	24.33	29.50	23.95	
	Swt potato	27.17	24.50	24.00	23.33	24.75	
	Means	25.61	22.00	21.38	22.55	**22.88**	
Ridge	Egusi melon	35.33	25.83	20.50	25.86	26.88	3.02
	Pumpkin	29.33	30.00	32.83	30.04	30.54	7.24
	Swt potato	30.33	25.66	25.00	26.29	26.82	5.78
	Means	31.66	26.91	26.11	27.43	**28.02**	
	Cover crop density means	28.83	24.45	23.74	24.99	**24.99**	

LSD 0.05 for 2 Seedbed means =2.15 LSD 0.05 for 2 a means at the same or different b =1.84
LSD 0.05 for 2 cover crop means= 1.54 LSD 0.05 for 2 a means at the same or different c =1.80
LSD 0.05 for 2 density means =0.96 LSD 0.05 for 2 b means at the same or different c =1.30
LSD 0.05 for 2 Seedbed means at the same or different levels of cover crop or densities =2.87
a =Seedbed, b = Cover crop species, c = (Cover crop) density

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Harnessing the potentials of bioresources biproducts in improving soil water holding capacity and plant germination index

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ABSTRACT

The world is moving towards innovation in harnessing bioresources materials into wealth for self-reliance without affecting the natural environment. The reason to give it keen attention. The aim of this study was to produce organic amendment from waste and its effects on soil properties and plant germination index. The aim was achieved by producing the organic amendment through composting processes where 5 kg of the mixed wastes was charged into a biodigester. Temperature, pH and moisture content were monitored throughout the process, and subsequently been converted into organic amendment after subjecting the matured compost through fermentation process, and the product was analyzed. The moisture content of the compost stabilizes at 50 % in which the temperature dropped from $50^{O}C$ to $25^{O}C$ at the maturity stage. The active microorganism identified in the produced amendment consist of bacteria and fungi with cell counts of 4.3×10^7 and 1.7×10^7 cell/g respectively, which enhanced the soil properties by improving its water holding capacity by 91 %, organic carbon by 84.5 %, average root length and shoot length of 1.46 and 5.66 cm respectively (organic amendment plant) from 0.3 and 0.6 cm for control. It is therefore, concluded based on the investigation carried out that, bioresources wastes were successfully converted into useful organic amendment to improve soil properties.

Key words: Organic amendment, water holding capacity, plant germination index

INTRODUCTION

There is a growing alarm on soil degradation, as universal need for food, water, energy, and raw materials persists at unparallel amount (Liu *et al*., 2019). The shortage of feat to meet up with these needs can be without difficulty result in unpleasant wave influence in human race. According to Corato, (2020), the universal land outlook approximates that one third of the universal land surface is harshly degraded, which has harmful effect on the comfort of no less than 3.2 billion populace traversing all continents. This leads to death of biodiversity and ecology services resulting to a financial loss of roughly 10 % of the globe's yearly overall produce in 2020 (Mendonca *et al*., 2021; Ballardo *et al*., 2021). These effects harmfully influence soil quality as the water holding capacity is abridged due to the soil structural instability (Adebayo *et al*., 2021; Heshan and Latif, 2021; Malta and Anna, 2021).

As reported by Abdulkadir *et al*., (2021); Xianfang *et al*., (2021; Pane and Anubha, (2021), the integration of bioresources waste directly on soil without adequate treatment is unsafe. However, composting by biological degradation is one of the best approaches used to achieve soil amendment (Gai *et al*., 2019; Kranz *et al*., 2020; Ghulam *et al*., 2021). More so, considering an average 98 million tons of agricultural waste and 28 million tons of animal waste been generated annually in Nigeria as reported by Choudhary *et al*., (2018); Asses *et al*., 2019; Ghulam *et al*., 2021; Anar *et al*., (2019) and Jangir *et al*., (2019) without adequately harnessing them through the waste management system, thereby adding to the existing environmental pollution problem and also depriving country the economic value of these waste into wealth potential. The need to utilize the abundance availability of these raw materials to justify this study. This work was aimed to produce organic amendment and study its impact on soil properties and germination index of plant.

MATERIALS AND METHODS

Characterization of the compost.

Total organic carbon (TOC), total nitrogen (TN), carbon to nitrogen ratio (C/N), available potassium (K_2O) and phosphorous (P_2O_5) of the compost pile were analyzed before and after composting process. The methods used were adopted from the work of Adebayo *et al*., (2019); Aftab *et al*., (2019); Gai *et al*., (2019).

Development of the organic Amendment

5 kg of compost pile, consisting of dried cow dung and jatropha (carrier) cake were charged into bioreactor in ratio of 70 % to 30 % for composting processes. The composting process was monitored in terms of temperature, pH and moisture content of the system for two weeks, after which fermentation process was done by dissolving mixture of 0.5 kg of brown sugar and 2 liters of water into the reactor. The solution was mixed and sealed tightly for 5 days, to form active substrate for the microorganism to strive. Sample was taken from the liquid product formed from fermentation process for analysis to ascertain the active microorganisms present after culturing using standard method and Kjeldahl digestion methods for the nutrient contents.

Soil texture determination

The particle size distribution was determined following the Bouyoucos hydrometer method as described by Ozlu and Kumar, (2018); of which 50 ml of 6 % H_2O_2 was added to 500 g of sieved soil sample in a beaker. The classification values are 480 gkg^-1, 320 gkg^{-1} and 200 gkg^{-1}, which is equivalent to 89.8 wt.%, 7.9 wt.% and 2.3 wt.% compositions respectively. The percentage of sand, silt and clay were computed using the following relationships and guided by adopting texture classification triangle.

$$\text{Clay (\%)} = \frac{Wc}{W} \times 100 \quad (1)$$

$$WC = R_{2HR} - R_B \quad (2)$$

$$\text{Silt (\%)} = \frac{Wsi}{W} \times 100 \quad (3)$$

$$Wsi = R_{40s} - R_B) - (R_{2HR} - R_B) \quad (4)$$

$$\text{Sand (\%)} = 100 - (\%\text{silt} + \%\text{clay}) \quad (5)$$

Where: W = weight of sieved soil sample, WC = weight of clay), R_{2hr} = 2 hrs hydrometer reading, R_B = blank hydrometer reading, R_{40S} = corrected forty seconds reading, Wsi = weight of silt.

Characterization of the soil and application of the organic amendment

The soil used was analyzed before and after using standard method described by Dukuziyaturemye *et al*., (2020), where 10 g of the produced organic amendment was weighed in ten different sample bottles, mixed with 100 ml of distilled water and then enthused for 24 hrs in each case. Samaize-37seeds were the specie of maize used in which two seeds were slumped in 9-cm-diameter petri dishes lined with a filter paper. Germination of seeds and length of root and shoot size dimensions were carried out after 72 h of the investigation, where the average values were recorded. Equations 6 and 7 were used to compute germination index and viror index.

$$\text{Germination index (GI)} = (10 \times n1) + (9 \times n2) + \cdots + (1 \times n10) \quad (6)$$

Where n1, n2……n10 = numbers of germinated seed on day 1, 2 until the 10^{th} day

$$\text{Vigor Index (VI)} = \text{Germination \%} \times (\text{mean root length} + \text{mean shoot length}) \quad (7)$$

RESULTS AND DISCUSSION

Characterisation of the Initial Co-compost Pile

Table 1 shows result of the characteristic of composting mixture of cow dung and jatropha cake before the composting process and afterward.

Table 1: The main characteristics of initial and final co-composting

Parameters	Before co-composting	After co-composting
Moisture content (%)	43.40	58.71
Total carbon (%)	27.65	22.98
Organic matter (%)	47.67	39.62
Total nitrogen (%)	2.42	3.43
P_2O_5 (%)	4.68	6.16
K_2O (%)	1.36	1.97

C: N	11.45	9.56
pH	5.7	7.8

As shown in the table, the initial moisture content of the compost pile was 43.40 %, it was increased to 58.71 % at the completion of the processes, which is within the range as reported by Corato, (2020). Chemical reaction occurs at this optimum moisture content in which microorganism activities are enhanced. The availability of sufficient nitrogen which was improved subsequently from 2.42 % to 3.43 % was responsible for synthesis of amino acids within the system. As observed from the results presented in Table 1, the availability of carbon was reduced from 27.65 % to 22.98 % due to its consumption during the composting process. Also, the organic matter load within the system was reduced from 47.67 % to 39.62 % by the activities of microorganism as shown in the table, which further justified the C: N values deprecation from 11.4 % to 9.56 %. These agree with trends reported in the work of Marta and Anna, (2021).

pH profile of the composting process

The variation in pH values of the composting system over 30 days investigating period was presented in Figure 1. As shown in the figure, during the mesophilic period (the first two days), the pH value was 7.91 after which it raised to 9.85 during the thermophilic stage. The rise in the pH value is due to the liberation of ammonia gas as a result of rapid breakdown of waste by microbes as reported by Adebayo *et al.*, (2018); Ballardo *et al.*, (2021); Marta and Anna (2021). However, the pH value at day 14th was observed to have reduced to 8.08. This may be as a result of the organic acids released and elevated amount of CO_2 absorbed into the system from the extreme breakdown of carbohydrates

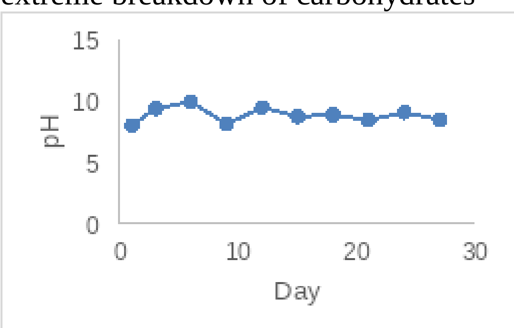

Figure 1: pH profile of the co-composing process

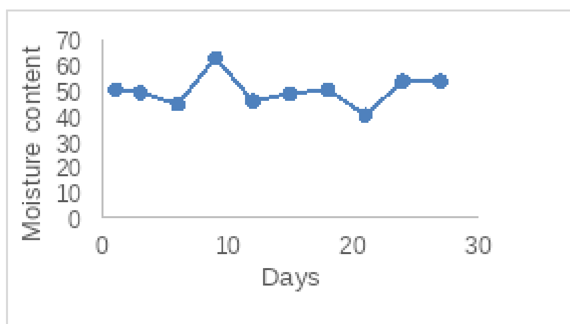

Figure 2: Moisture content profile of the co-composting process

Moisture content profile of the co-composting process

As shown in Figure 2, the initial moisture content of the compost system was 50 %, which is considered minimum as reported in the work of Liu *et al.*, (2019). As observed from the figure on the 3rd and 5th day of composting, the moisture content reduced to 45 % and 44 % respectively. The moisture content continued to reduce and increase during the observation as shown in Figure 2 until it stabilizes on 50 % from days 25th to 29th. These trends which is similar to Pane and Anubha, (2020) report is due to the activities of microbe to completely break down of the organic matter until maturity stage was achieved.

Temperature profile of the co-composting process

As shown in Figure 3, the initial temperature increased from 28^0C to 47.80^oC at the 7^{th} day of composting as a function of the microorganism activities within the system, which is in agreement to the report of Ghulam *et al.*, (2021). The temperature of the composting system rose to 50.20^oC on the 9^{th} day as a result of intense decomposition of the available organic matter, which is sufficient enough to eliminate any pathogen present in the system before it was reduced 25^0C from the 23^{rd} day until the process remain linear, signifying the maturity stage.

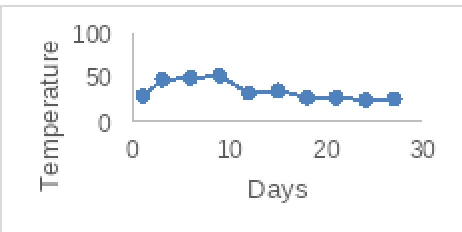

Figure 3: Temperature profile of the co-composting process

Biochemical analysis of the produced organic amendment

The microbial analysis of organic fertilizer is shown in Table 2. As shown in the table, the active microorganisms in the produced organic amendment are *Bacillus SP* (bacterial) with cell count of 4.3×10^7 cell/g which helps in maintaining mesophilic temperature. Also, the active fungi present are *Aspergillus Fumigatus, Aspergillus Versicolor and Penicillium SP* with the same cell count of 1.7×10^7 cell/g. These fungi present are the microorganism that continuously recycling carbon and nitrogen as reported in the work of Kranz *et al*., (2020).

Table 2: Biochemical analysis results of the produced organic amendment

Active microorganism	Microorganism type	Cell count (cell/g)	Function	Moisture content (%)
Bacillus SP	Bacteria	4.3×10^7	P-solubilizer	40
Penicillium SP	Fungi	1.7×10^7		
Aspergillus versicolor	Fungi	1.7×10^7		
Aspergillus fumigatus	Fungi	1.7×10^7		

Characteristics of the soil before and after application of organic fertilizer

As shown in Table 3, the amount of sand, silt and clay in the experimented soil sample classification were 480 gkg^{-1} 320 gkg^{-1} and 200 gkg^{-1} respectively. The relative proportions of sand silt and clay content indicated the loam texture of the soil as shown by the United State Division of Agricultural textural triangle.

Table 3: The main characteristics of the experimental soil

Soil characteristics	Value (Before application)	Value (After application)
Sand (gkg^{-1})	480	
Silt (gkg^{-1})	320	
Clay (gkg^{-1})	200	
Soil texture	Sandy loam	
pH	6.5	7.3
Carbon (gkg^{-1})	1.5	9.7
Water holding capacity (%)	0.49	5.3

As shown in Table 3, the organic carbon in the soil was 1.5 gkg^{-1} which is very low compared with the standard specification of >15 as reported by Xianfang *et al.*, (2021). The low organic carbon content observed may be attributed to the exhaustion of the organic matter in the soil as a result of soil degradation by continuous cropping without replenishing the used nutrients which were loss during soil leaching. The improvement of the organic carbon through the effect of incorporated amendment does not meet the required specification, however, the effect was shown as it was increased by 91 % which proved that, the soil amendment was good. Also, the low water holding capacity was improved from 0.49 % to 5.3 % due to the impact of the amendment as shown in Table 3.

Impact of the organic amendment on germination index of plant

Table 4 show the impact of organic amendment on plant roots and shoot lengths growth and that of control sample. As presented in the table, the root length for plant 1 in the organic amendment incorporated plant was 0.9 cm which is 33.3 % higher than the one in a control sample when compared based on the same experimental treatment condition. Also 1.9 cm root length was observed for plant 2 in organic amendment plant while 0.5 cm was recorded in the control sample as shown in Table 4. More so, the trends in shoot length of all the plants in organic amendment incorporated sample are better in terms of productivity and yield when compared to of control samples. The evidence was observed on the average shoot length of 5.66 cm as compared to 0.6 cm in a control sample. Therefore, the effect of organic amendment on the soil and plant roots can be justify with efficiency of the improved soil properties as observed in this investigation.

Table 0: Average root and shoot lengths in organic amendment and control plants experiment

	Organic amendment incorporated plants		Control plants	
Plant	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)

1	0.9	2.6	0.6	1.0
2	1.9	7.7	0.5	1.1
3	1.5	8.6	0.5	1.0
4	1.9	2.9	0.3	0.7
5	1.1	6.0	0.0	0.2
6	1.8	7.5	0.2	0.5
7	2.3	9.5	0.0	0.1
8	0.7	3.0	0.4	1.5
9	1.1	4.1	0.1	0.5
10	1.4	4.7	0.4	0.5
Average	1.46	5.66	0.3	0.6

Plate I (a and b) show some of the plant roots investigated during the experimental process

Plate I: Plant roots of the (a). organic amendment sample and (b). Control sample

CONCLUSION

It can be concluded at the end of this investigation that, the produced organic amendment characterized with 40 % moisture content contained *bacillus SP*, *penicillium SP*, *aspergillus versicular* and *aspergillus fumigatus* as its active microorganism. More so, the produced organic amendment improved the water holding capacity of the soil by 91 % and the soil organic carbon by 84.5 % which are functions of the average root and shoot lengths of 1.46 cm and 5.66 cm respectively recorded for organic fertilizer amended soil compared to the 0.3 cm and 0.6 cm average lengths obtained for the control sample. Therefore, the produced amendment impacted the soil efficiently.

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Assessment of the Decentralized Vine Multipliers Model as Pathway for Sweet Potato Seed System Development in Abia State, Nigeria

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ABSTRACT

The study assessed the Decentralized Vine Multipliers (DVMs) model as pathway for sweet potato seed system development in Abia State. Multi stage random sampling technique was used to elicit responses from the farmers. Two blocks from each of the three zones and two circles from each block were randomly selected making it twelve (12) circles. Ten (10) Sweet potato DVMs were randomly selected from each circle, giving a total of 120 farmers for the study. Primary and secondary data were used for the study. Data were analyzed using descriptive statistics such as percentages, and means and were presented in tables and charts. Results revealed that DVMs were trained on good agronomic practices but no training on business management practices and lack of National Agricultural Seed council (NASC) certification leading to absence of guaranteed quality assurance. The DVMs were also trained on vine production using net tunnel for pre-basic vine production, maintenance operations on sweetpotato vines, cost effective net tunnel and vines in containers in the net tunnel. The DVMs produced improved sweetpotato varieties such as UMUSPO 3, UMUSPO 4, TIS 87/0087, Ex-Igbariam, UMUSPO 1 and TIS 8164. The study revealed that major constraint to sweet potato vine production faced by the DVMs were access to market, inadequate input, lack of capital and low market price of vines. It was recommended that DVMs should form clusters to enable them attend regular trainings on good agricultural practices and business management to ensure high yields and certification by the NASC in order to attract guaranteed market for sustainable sweet potato early Generation Seed (EGS) business.

Key words: Assessment, Sweet potato, Decentralized Vine Multipliers and Seed System.

INTRODUCTION

Sweet potato *(Ipomoea balatas*(L)) is a herbaceous, warm-weather creeping plant that belongs to the family of *Convolvulaceae* and genus of *Ipomoea* (Mbanasor, 2010). In 2018 Nigeria produces 3.9 metric tons of sweet potatoes and is the largest producer in sub-Saharan Africa (Shanhbanden, 2018). In recent times, the West Africa region has witnessed increase in crop output; sweet potato recorded a positive per capita annual rate of increase in production in sub-Saharan Africa (Ndaula *et al*., 2020). The Decentralized Vine Multipliers Model was introduced as a means of scaling out clean sweet potato vines through the relevant stakeholders to the farmers to ensure high yield and productivity by farmers. The DVMs are comprised of farmer associations, out-growers, Non-governmental organizations (NGOs), cooperative societies and other seed producers with strong interest in sweet potato vine production in many sweet potato growing ecologies of Nigeria. The collaboration between the International Potato Centre (CIP) and National Root Crops Research Institute (NRCRI) during the Sweet Potato Action for Security and Health in Africa (SASHA), a five-year initiative which had the objective to improve the food security and livelihoods of poor families in sub Saharan Africa by exploiting the untapped potential of sweet potato. The decentralized vine multipliers model has greatly improved in capacity and output since its introduction in sweet potato seed production in Nigeria. The DVMs were trained and equipped with net tunnels for the production and sale of clean vines. The net tunnel is specially designed to ward off pests and diseases at the pre- basic level of vine multiplication. There is need for the study to know how decentralized vine multipliers model has gone far in development of sweet potato seed system.

Figure 1. Net tunnel for Pre Basic Vine Production

Figure 2. Maintenance operations on sweetpotato vines

Figure 3. Cost effective Net Tunnel

Figure 4 Vines in containers in the net Tunnel

METHODOLOGY

The study was carried out in Abia State (Aba, Umuahia and Ohafia agricultural zones). Abia State lies between longitude 7^0 $00^0$and 8^010^1 East and latitude 4^0 45^1 and 60^0 10^1 North. It occupies a land mass of 5,833.77 square kilometers (ABSEEDS, 2006). Multi stage random technique was used to elicit data from the farmers. The three agricultural zones were involved. Two blocks from each zones were randomly selected; two circles were also randomly selected making it twelve (12) circles. Ten (10) Sweet potato DVMs were randomly selected from each circle, making a total of 120 farmers for the study. Primary and secondary data were used for the study. Data were analyzed using descriptive statistics such as percentages and mean.

Sweet Potato Seed Flow

In the sweet potato seed flow, the major flow is from the Research Institute (NRCRI Umudike) to the decentralized vine multipliers, sweet potato farmers' cooperatives, ADPs and sweet potato farmers. National Root Crops Research Institute produces and supplies clean Pre-Basic seeds at moderate price. Farmers also save some of their seeds which they utilize in planting the next year. Famers saved seeds are of low productivity and are not resistance to pest and diseases.

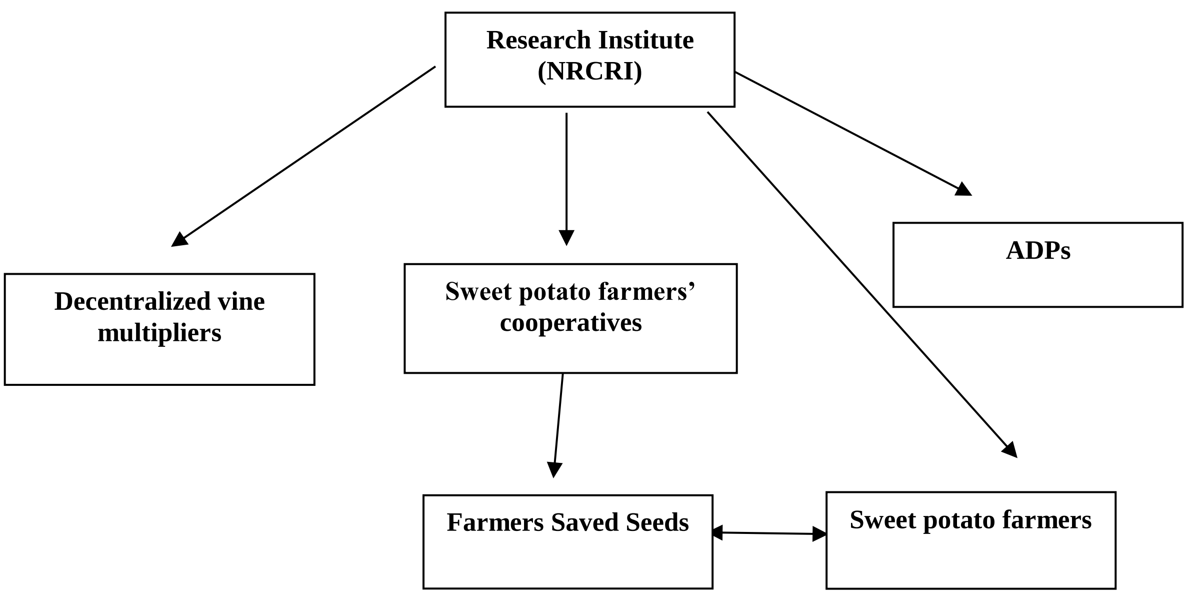

Fig. 5. Sweet Potato Seed Flow

Sweet Potato vine produced by the DVMs

From the chart below the major sweet potato vines produced by DVMs in Abia State was UMUSPO 3(33%), followed by UMUSPO 4 (19%), TIS 87/0087 (17%), Ex-Igbariam (12%), UMUSPO 1 (9%), UMUSPO 2 (6%) and TIS 8164 (4%). This result showed that the DVMs were producing improved sweet potato varieties in the study area.

These Are Improved Varieties of Sweet Potato, High Yielding and Resistant to Pest and Diseases.

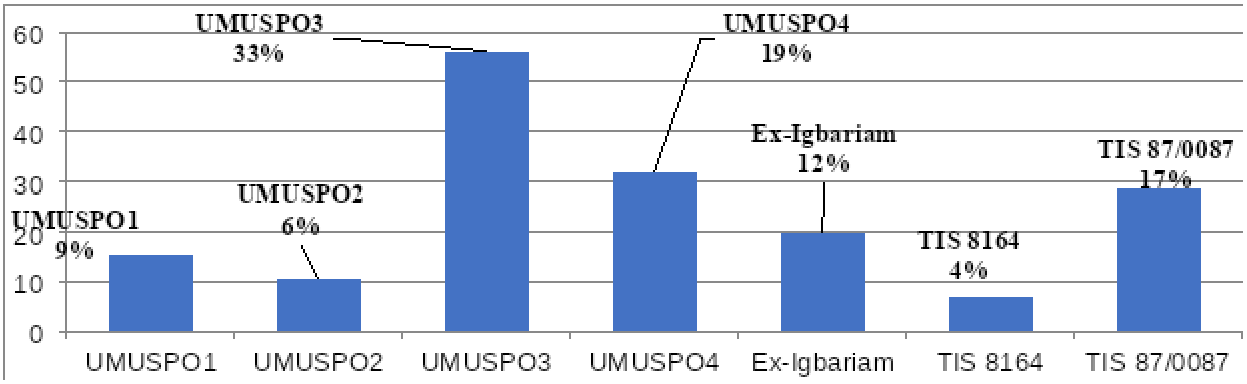

Figure 6
Source: Field survey, 2019.

Quality of Sweet Potato Vines Produced by Sweet Potato Vine Multipliers

- The sweet potato seeds produced by the Decentralized vine multipliers were not certified.
- The vines were healthy, free from pest and diseases.
- No NASC certification of vines yet.

Training on Improved Agronomic

The Decentralized vine multipliers have been trained on improved agronomic practices and the DVMs participated in the training. The result showed that all the DVMs 100% participated in harvesting of vines, followed by planting (80%), ridging/ bed making (76%), weeding (70%) land clearing (60%), site selection (58%) and fertilizer application (50%). There was no training on business management. This shows that the DVMs had training on good agronomic practices on sweet potato vine production. This finding agrees with the report of Ukoha *et al.* (2016) that farmers participate in trainings to equip and keep them abreast with major happenings in the field of agriculture.

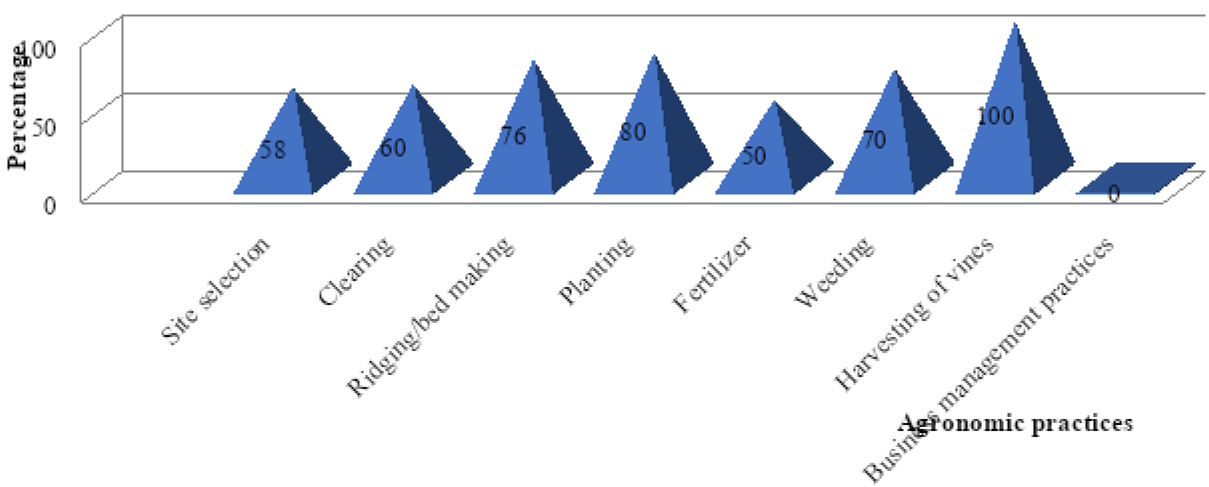

Figure 7.
Source: field survey, 2019.

Challenges to Sweet Potato Seed Production and Marketing

Table 1 revealed that the major challenges to sweet potato vine production and marketing in Abia State were lack of capital, inadequate inputs, lack of sweet potato seed market and low market price for sweet potato seed. These challenges have made it difficult for farmers to expand their scale of production in sweet potato seed business in the state. According to Oni (2013), identification of the constraints or challenges in the agricultural sector is a necessary step to unlock the factors inhibiting performance of the sector towards promotion and growth of the sector.

Table 1. Challenges to Sweet Potato Seed Production and Marketing

Challenges (three point rating scale of very serious, serious and not serious)	Mean Score
Availability of improved varieties of sweet potato seeds	1.2
Lack of capital	2.5
Access to credit facilities	2.0
Inadequate inputs	2.6
High cost of labour	2.0
Access to market	2.8
Low market price	2.5
Pests and diseases	1.0
High cost of improved planting materials	1.8
Soil fertility	1.5

Source: field survey 2019. Note: Major challenges ≥ 2.0, Not a challenge < 2.0

CONCLUSION

The study concluded that the Decentralized Vine Multipliers were trained on good agronomic practices, the business model was not effective due to lack of training for DVMs on business management, inadequate inputs, lack of sweet potato seed market, low price of sweet potato vines. Therefore, it was recommended that farmers should make effort to form clusters of sweet potato vine multipliers to enable them attend regular trainings on good agricultural practices and business management to ensure high yields and quality assurance through certification by the National Agricultural Seed Council (NASC).

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Effect of sawdust on atrazine and nicosulfuron residues in the soil using *Celosia argentea* as a test crop

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ABSTRACT

Atrazine and nicosulfuron are persistent herbicides widely used for weed management in maize. The persistence of these herbicides extends the duration of weed control but may injure associated and follow-up crops of maize. Hence, soil amelioration may be necessary to deter the phytotoxic effect of herbicide residue on these crops. A screenhouse experiment was conducted to investigate the effect of sawdust on atrazine and nicosulfuron residue in the soil using *celosia argentea* as a test crop. A 4 x 5 factorial experiment was laid out in a completely randomised design with four replicates. The first factor comprised four herbicide levels: herbicide-free (control), atrazine at 3.0 kg a.i ha^{-1}, nicosulfuron at 40 g a.i ha^{-1}, and a mixture of atrazine and nicosulfuron at 750 g a.i ha^{-1} and 60g a.i ha^{-1}, respectively. The second factor comprised five levels of sawdust; 0% (control), 5%, 10%, 15%, and 20% by volume in the potting soil. The number of celosia leaves per plant and the plant heights were recorded weekly from 3 weeks after transplanting (WAT) to 6 WAT. The fresh and dry weights of the celosia plants at 6 WAT were also recorded. Findings indicated that residues of the herbicide levels in the soil did not significantly (P<0.05) reduce the number of leaves, plant height and fresh weight of celosia. However, nicosulfuron impacted the dry weight of celosia shoots negatively. Sawdust at a low proportion of 5% and 10% improved celosia growth, whereas a 20% proportion reduced celosia growth. The interaction of atrazine and nicosulfuron with 5% sawdust resulted in enhanced growth and yield of celosia over untreated soil. Hence, for the follow-up crops of maize, the addition of 5% sawdust is recommended within the rooting depth of atrazine and nicosulfuron-treated soil.

INTRODUCTION

Atrazine and nicosulfuron are selective herbicides used for weed management in maize production (Akadiri et al., 2017). The persistence of these herbicides in the soil may negatively affect the growth of vegetables cultivated in maize plots in a relay cropping system or as catch crops (Aladesanwa, 2001; Mamnoie, 2021). Increasing the pre-plant interval to avoid reduced vegetable yield in atrazine and nicosulfuron-treated plots may invalidate the fitness of vegetables for the relay cropping system. Hence, it is imperative to alleviate the harmful effect of herbicide residue by reducing its availability to sensitive vegetable crops without significantly disrupting the sowing dates.

Organic matter is an important absorbent for herbicides (Spark & Swift, 2002). Applying soil organic amendments may increase herbicide persistence by increasing the sorption process (Mehdizadeh et al., 2019). However, the sorption of herbicides by organic matter makes them less available for plant uptake (Williams et al., 2001). Celosia (*Celosia argentea*) is a commonly cultivated vegetable in Nigeria and has been reported to be sensitive to atrazine and nicosulfuron (Aladesanwa et al., 2001; Mishra et al., 2016). Hence, this study investigated the effect of sawdust on atrazine and nicosulfuron residues using celosia as a bioassay.

MATERIALS AND METHODS

Collection of materials and preparation of potting media

Seeds of *Celosia argentea* (TLV 8) were sourced from the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. The seeds were stored in a paper bag and kept in a dry environment before planting. Topsoil within 0-15cm depth was collected from the Faculty Garden of Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria. The soil was air-dried, sieved with 2mm mesh, and used to fill polythene plant pots measuring 5 cm x 3 cm. In preparing the potting media, ratio-based volume mixing of topsoil and sawdust was adopted. Each sawdust level (0%, 5%, 10%, 15%, and 20%) was used to fill sixteen pots. Hence, eighty filled pots were arranged 1 m apart in the screenhouse. The topsoil used is a sandy clay loam with a neutral pH, 0.96% organic carbon, 1.65% organic matter, 0.08% nitrogen, 3.5 mg kg^{-1} phosphorus, and 0.61 mg kg^{-1} potassium. The soil's sodium, calcium and magnesium contents were determined to be 0.81, 1.4 and 0.7 cmol kg^{-1}, respectively. The sawdust had 94.82% organic carbon, 5.24 mg kg^{-1} phosphorus, and 2.77 mg kg^{-1} potassium. The sawdust's sodium, calcium and magnesium contents were analyzed to be 2.61, 3.21 and 1.86 cmol kg^{-1}, respectively.

Experimental design and treatments

A 4 x 5 factorial experiment in a completely randomised design (CRD) was laid out in a screenhouse at Adekunle Ajasin University, Akungba-Akoko, Nigeria and replicated four times. The first factor comprised four herbicide levels; herbicide-free (control), atrazine at 3.0 kg a.i ha^{-1}, nicosulfuron at 40 g a.i ha^{-1}, and a mixture of atrazine and nicosulfuron at 750g a.i ha^{-1} and 60g a.i ha^{-1}, respectively. The second factor comprised five levels of sawdust in the potting topsoil; 0% (sawdust-free control), 5%, 10%, 15%, and 20%.

Herbicide application in the screenhouse

For per hectare herbicide application proration, four plots measuring 1 m x 1 m each were marked out in the screenhouse. Twenty pots were arranged within each plot such that the five levels of sawdust were replicated four times. Thereafter, different herbicide levels were singly applied to each plot using a knapsack sprayer. Only water was applied to the herbicide-free control.

Transplanting of celosia seedling

Two weeks after sowing (WAS), celosia seedlings at a two-leaf stage were transplanted from the nursery to the potted soil in the screenhouse. The seedlings were transplanted six weeks after herbicide application. The bed was watered thoroughly before transplanting to avoid root damage. Transplanting was done in the morning to reduce water loss through transpiration.

Data collection and analysis

The height and number of leaves of celosia were recorded weekly, starting from 3 weeks after transplanting (WAT) and continued till 6 WAT. Celosia plants were uprooted and analyzed for fresh and dry weight at 6 WAT when the plants had attained commercial maturity. Data obtained were subjected to Analysis of Variance using SPSS version 23 software. The treatment means were separated using Duncan Multiple Range Test at a 5% probability level.

RESULTS

Effect of herbicide residue on growth and yield of celosia

Generally, the number of leaves per plant and height of celosia increased progressively with plant age. There was no significant difference ($P<0.05$) in the number of leaves at the herbicide levels at 3 WAT and 6 WAT, unlike 4 WAT and 5 WAT (Figure 1a). Atrazine had the highest number of leaves per plant at 4 WAT (11 leaves) and 5 WAT (25 leaves). Its number of leaves was significantly ($P<0.05$) higher than herbicide-free control and all herbicide levels at 4 WAT and 5 WAT, respectively. The number of celosia leaves recorded per plant in the herbicide-treated soil was not significantly ($P<0.05$) lower than in the herbicide-free soil throughout the trial.

Celosia plant heights were significantly ($P<0.05$) different across the herbicide levels at 3, 5, and 6 WAT (Figure 1b). At the aforementioned stages in the trial, atrazine had the highest celosia plant height (3.44 cm, 8.78 cm and 14.39 cm) and its celosia plant heights were significantly higher than the herbicide-free control (2.47 cm, 6.09 cm and 9.82 cm) which had the least.

There were no significant differences ($P<0.05$) in the fresh weights of celosia among the herbicide levels at 6 WAT (Figure 1c). Hence, the effect of herbicide residue on the fresh weight of celosia was insignificant. Celosia plants in potted soil treated with atrazine had the highest fresh weight of shoot (11.4 g) and root (2 g), while nicosulfuron had the least (5.6 g and 1 g, respectively). The dry weights of celosia shoot and root were significantly different ($P<0.05$) at 6 WAT (Figure 1d). Celosia plants in herbicide-free control had the highest dry weight of celosia shoot and root (1.05 g and 0.35 g). Herbicide-free control had a significantly higher weight of celosia shoot and root than nicosulfuron (0.42 g and 0.18g), which had the least. The dry shoot and root weight of celosia in nicosulfuron-treated soil were significantly reduced ($P<0.05$) compared to herbicide-free control. However, the atrazine-nicosulfuron mixture and atrazine had comparable celosia dry weights with the herbicide-free control.

Effect of sawdust on growth and yield of celosia

The number of leaves and plant height of celosia were significantly different ($P<0.05$) among the sawdust levels from 3 WAT to 6 WAT (Figure 2a&b). Throughout the trial, the highest number of celosia leaves (8, 14, 31, and 49 leaves) were recorded from 5% sawdust. Contrarily, 20% sawdust had the least number of celosia leaves (4, 5, 7 and 14 leaves), and it was significantly ($P<0.05$) lesser than 5% sawdust throughout the trial. Notably, 20% sawdust resulted in a significantly ($P<0.05$) reduced number of leaves at 3 WAT and 4 WAT compared to sawdust-free control (0% sawdust). However, it had a comparable number of celosia leaves per plant with sawdust-free control at 5 WAT and 6 WAT. Judging by the sawdust-free control, the 10% sawdust and 15% sawdust resulted in a significantly increased and a comparable number of celosia leaves, respectively.

Similarly, weekly results from 3 WAT to 5 WAT showed that 5% sawdust had the highest celosia plant height (4.09 cm, 6.94 cm, 10.77 cm and 17.71 cm). It was significantly ($P<0.05$) different from 20% sawdust which had the least plant height. The 5% sawdust and 10% sawdust resulted in celosia plant height significantly higher than the sawdust-free control (0% sawdust), whereas 15% sawdust and 20% sawdust resulted in a comparable plant height and a significantly reduced ($P<0.05$) celosia plant height, respectively.

The fresh and dry weights of celosia across the sawdust levels were significantly different at 6 WAT (Figure 2c&d). The 5% sawdust had the highest shoot, root and total fresh weight (15.94 g, 3.06 g and 19 g), whereas the lowest shoot, root, and total fresh weights were recorded in 20% sawdust (1.94 g, 0.06 g and 2 g). The shoot, root and total fresh weights that resulted from 5% sawdust were significantly higher than the sawdust-free control, whereas 10%, 15% and 20% sawdust had a comparable shoot, root, and total fresh weight. The dry weight of the celosia plant followed the same trend as the fresh weight across the sawdust levels.

Interaction of herbicide residue and sawdust on growth and yield of celosia

The number of celosia leaves differed significantly ($P<0.05$) among the herbicide and sawdust interactions. (Table 1). Based on weekly results, atrazine and 5% sawdust (A+S5%) recorded the highest number of celosia leaves from 3 WAT to 6 WAT (9, 21, 47, and 64 leaves). In contrast, atrazine and 20% sawdust (A+S20%) had the lowest number of celosia leaves at 3 WAT and 4 WAT (3 and 5 leaves). The interaction of nicosulfuron and 20% sawdust (M+S20%) resulted in the lowest number of celosia leaves at 5 and 6 WAT (7 and 11 leaves). Remarkably, the number of celosia leaves from atrazine and 5% sawdust (A+S5%) interaction was significantly higher ($P<0.05$) than in untreated soil (C+S0%) and herbicide-free soil with 5% sawdust (C+S5%). Also, untreated soil (C+S0%) had a comparable number of celosia leaves with all other interactions, except for the significantly increased number of celosia leaves at 4 WAT and 5 WAT by nicosulfuron and 5% sawdust (N+S5%) and interaction of atrazine and 10% sawdust (A+S10%) at 5 WAT.

The plant height of celosia differed significantly ($P<0.05$) with respect to herbicide and sawdust interaction. The interactions of atrazine and 5% sawdust (A+S5%) and nicosulfuron and 5% sawdust (A+S5%) had the highest celosia plant height at 3 WAT (5.25 cm) and 6 WAT (22.85 cm). Also, atrazine and 5% sawdust (A+S5%) resulted in the highest celosia plant height at 4 WAT (9.18 cm) and 5 WAT (14 cm). Notably, throughout the study, atrazine and 5% sawdust (A+S5%) had a significantly higher height of celosia plants than untreated soil (C+S0%). A similar trend was also found in nicosulfuron and 5% sawdust (N+S5%). None of the interactions had significantly ($P<0.05$) reduced celosia plant height compared to the untreated soil (C+S0%).

The fresh and dry weight of celosia per plant differed significantly ($P<0.05$) among the interactions of herbicide and sawdust. Atrazine and 5% sawdust (A+S5%) had the highest fresh shoot, root and total weight (26.75g, 5g and 31.75g) among the interactions. The least fresh shoot, root and total weights (1.25g, 0.10g and 1.35g) were found in nicosulfuron and 20% sawdust. However, the least fresh shoot, root and total weights were comparable with untreated soil (3.50g, 0.75g and 4.25g).

Herbicide-free and 5% sawdust (A+S5%) had the highest dry shoot, root and total weights of celosia (2.97g, 1.06g and 4.03g) among the interactions. The interaction of nicosulfuron and 20%

sawdust had the least dry shoot, root and total weight of celosia (0.08g, 0.02g and 10c), and it was comparable with the untreated soil (C+S0%).

DISCUSSION

This study showed that celosia could be transplanted into atrazine-treated soil six weeks after treatment without a decrease in yield. The transient increase observed in the growth parameters of celosia plants in atrazine-treated soil might have resulted from the hormetic effect (low dose stimulation and high dose inhibition of growth) of atrazine residue. Lytle & Lytle (2005) observed stimulatory growth in *Sesbania vesicaria* and *Vigna luteola* exposed to low concentrations of atrazine. The absence of atrazine phytotoxicity in this study might have resulted from the mitigated concentration of atrazine through decomposition and sorption. Atrazine catabolism and sorption by soil components reduce the concentration of atrazine in the soil, thus causing the stimulatory effect at a low concentration.

The reduced dry weight of celosia in nicosulfuron-treated soil was probably due to the phytotoxicity of nicosulfuron residue. Rahman et al. (2011) reported that nicosulfuron residue reduced the dry weight of mustard plant (*Sinapis alba*), unlike atrazine applied on the same day. The use of herbicide mixture for weed management is justified in this study as soil residue of atrazine and nicosulfuron mixture was not phytotoxic to celosia even at a higher concentration of nicosulfuron, which solely reduced celosia dry weight.

For a longer duration of this trial, the improved growth of celosia in soil treated with 5% and 10% sawdust was probably due to the ability of sawdust to decrease the soil bulk density and increase the soil organic carbon content. The decrease in celosia growth caused by 20% sawdust could be attributed to nitrogen immobilization commonly associated with soil amendments with a high carbon-to-nitrogen ratio (Iroegbu et al., 2020). This study corroborates the findings of Siddiqui & Alam (1990) that sawdust as soil amendment improves the growth of plants.

The comparable growth of celosia in atrazine-treated soil without sawdust and untreated soil disagrees with Aladesanwa et al. (2001), who reported reduced growth of celosia sown within twelve weeks pre-plant interval on atrazine-treated soil. It is opined that the difference in the soil textural class used for this study may be responsible for this different outcome. Further studies on the role of the higher clay content in the soil may provide more helpful information. The improved growth of celosia resulting from the interaction of atrazine and nicosulfuron with 5% sawdust over the interaction of herbicide-free and 5% sawdust indicates the synergistic effect of 5% sawdust and residues of atrazine and nicosulfuron.

CONCLUSION

The soil residues of atrazine and atrazine-nicosulfuron mixture are not injurious to celosia transplanted at a pre-plant application interval of six weeks. Using a mixture of atrazine and nicosulfuron for weed management in maize mitigates the phototoxic effect of sole nicosulfuron residue on follow-up celosia. Applying 5% sawdust to atrazine and nicosulfuron-treated soil improves celosia growth.

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Figure 1: Effect of herbicide residue on growth and yield of celosia

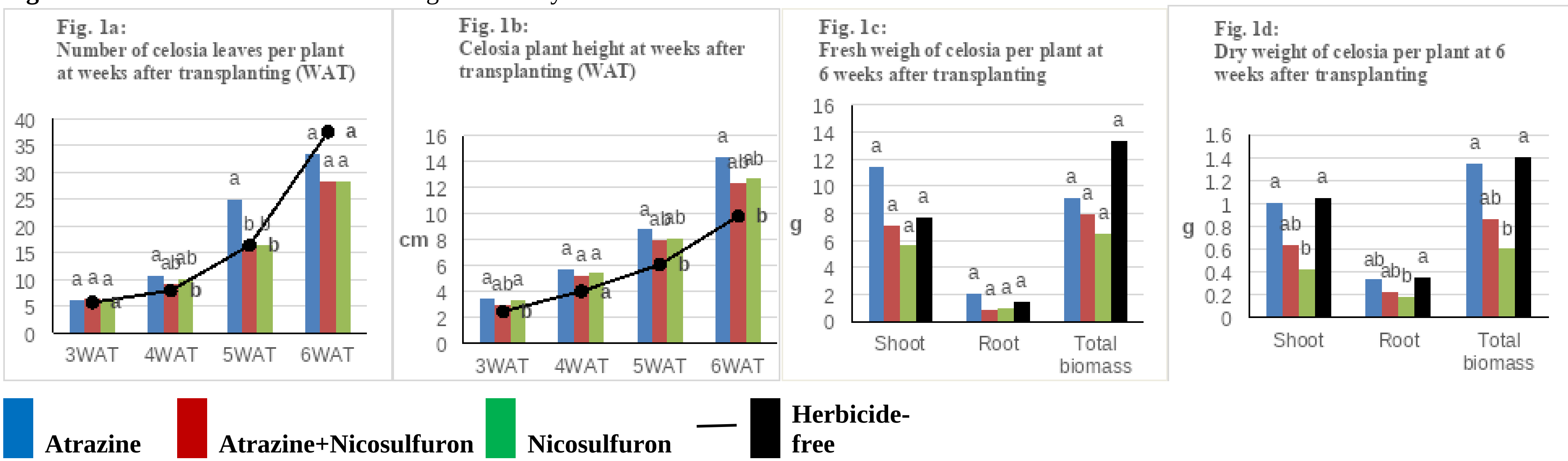
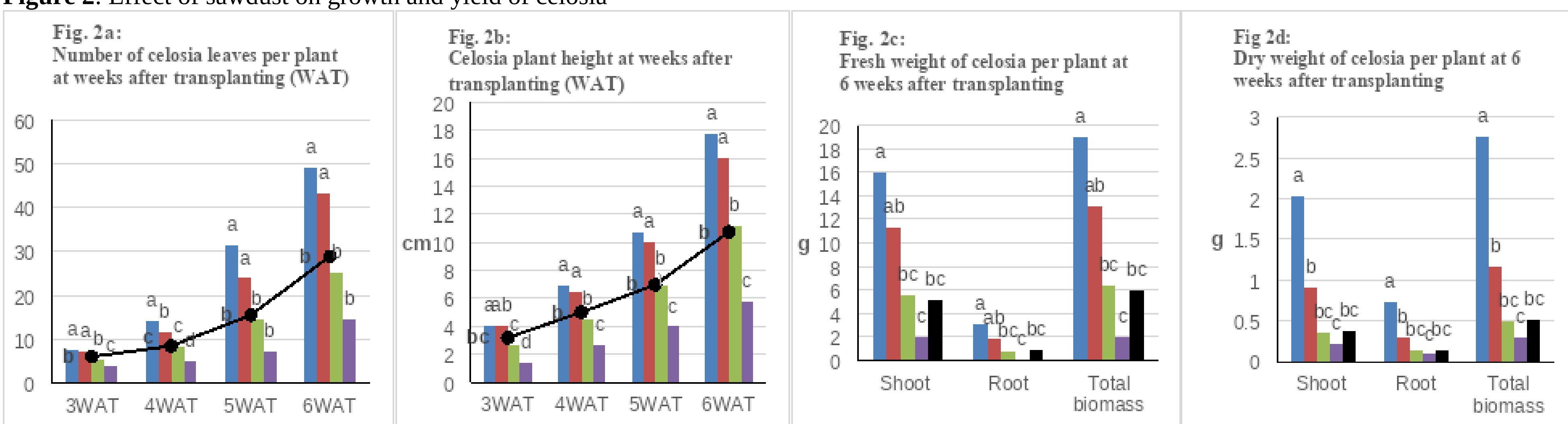


Figure 2: Effect of sawdust on growth and yield of celosia



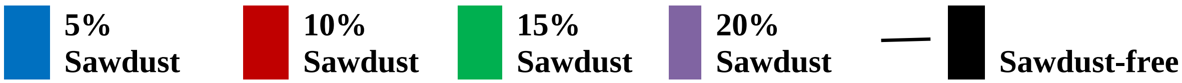

5% Sawdust
10% Sawdust
15% Sawdust
20% Sawdust
Sawdust-free

Table 1: Interaction effect of herbicide and sawdust on growth and yield of celosia

Treatment	Number of leaves (plant^{-1})				Plant height (cm)				Fresh weight @ 6WAT (g/plant)			Dry weight@6WAT (g/plant)		
	3WAT	4WAT	5WAT	6WAT	3WAT	4WAT	5WAT	6WAT	Shoot	Root	Total	Shoot	Root	Total
A + S0	4.75d-g	7.25c-e	16.50b-d	24.75b-d	3.00b-f	4.95c-g	7.13b-e	11.13c-f	5.25bc	0.50bc	5.75bc	0.36bc	0.13cd	0.49bc
A + S5	9.00a	21.00a	46.75a	64.00a	5.25a	9.18a	14.00a	22.85a	26.75a	5.00a	31.75a	2.97a	0.91a	3.64a
A + S10	7.00a-e	12.00c	32.50ab	49.75a-e	4.10ab	6.78a-c	10.95ab	19.18a-c	13.50a-c	2.25a-c	16.00a-c	1.11bc	0.31b-d	1.43bc
A + S15	6.50a-f	9.00c-e	21.00b-d	33.00a-e	3.65a-c	5.38c-g	8.25b-e	13.50b-f	9.50bc	1.75bc	11.25bc	0.59bc	0.21b-d	0.80bc
A + S20	3.25g	4.50e	7.75d	16.50c-e	1.20f	2.68fg	3.58e	5.80f	2.00c	0.25bc	2.25c	0.23bc	0.09cd	0.32bc
M + S0	8.25a-c	11.50c	23.00b-d	42.75a-e	3.55a-d	6.33a-d	9.20a-d	14.75a-f	9.00bc	1.25bc	10.25bc	0.75bc	0.29b-d	1.04bc
M + S5	7.00a-e	10.50cd	25.25b-d	42.75a-e	3.23b-e	5.70b-f	9.45a-c	16.00a-d	14.75a-c	3.00a-c	17.75a-c	1.36bc	0.36b-d	1.72bc
M + S10	7.25a-d	10.50cd	16.25b-d	28.25b-e	3.93ab	6.88a-c	9.75a-c	14.00a-f	6.50bc	0.25bc	6.75bc	0.45bc	0.20b-d	0.65bc
M + S15	5.00d-g	7.75c-e	11.25cd	27.75b-e	2.45b-f	4.58c-g	7.33b-e	10.63c-f	3.50bc	0.30bc	3.5bc	0.24bc	0.09cd	0.33bc
M + S20	4.00fg	5.25de	7.00d	13.25de	1.60d-f	2.93e-g	4.15de	6.08ef	1.75c	0.32bc	2.07c	0.35bc	0.19b-d	0.55bc
N + S0	5.50c-g	7.50c-e	11.25cd	19.75c-e	3.25b-e	4.75c-g	5.63c-e	7.95d-f	2.75bc	1.05bc	3.75bc	0.14c	0.05cd	0.19c
N + S5	5.50c-g	17.50ab	32.50ab	45.25a-d	5.25a	8.58ab	13.75a	22.85a	11.50bc	2.00a-c	13.50bc	1.09bc	0.56b	1.65bc
N + S10	7.50a-d	12.75bc	17.50b-d	28.25b-e	4.3ab	6.50a-c	10.25a-c	15.38a-e	7.75bc	1.00bc	8.75bc	0.47bc	0.17cd	0.64bc
N + S15	5.00d-g	8.00c-e	14.00b-d	27.75b-e	2.60b-f	4.75c-g	6.43b-e	11.75c-f	4.50bc	0.75bc	5.50bc	0.32bc	0.09cd	0.47bc
N + S20	3.50g	4.75e	6.50d	10.50e	1.28ef	2.55g	4.15de	5.33f	1.25c	0.10c	1.35c	0.08c	0.02d	0.10c
C + S0	**5.50c-g**	**7.50c-e**	**11.25cd**	**25.25b-e**	**2.93b-f**	**4.01c-g**	**`5.95b-e**	**9.20d-f**	**3.50bc**	**0.75bc**	**4.25bc**	**0.27bc**	**0.08cd**	**0.34bc**
C + S5	6.00b-g	8.00c-e	20.75b-d	44.25a-e	2.63b-f	4.38c-g	5.88b-e	9.65d-f	10.75bc	2.25a-c	13.00bc	2.97a	1.06a	4.03a
C + S10	7.25a-d	10.50cd	29.75a-c	57.00ab	3.65a-c	5.88b-e	9.13a-d	15.55a-d	17.25ab	3.50ab	20.75ab	1.57b	0.45bc	2.03b
C + S15	5.50c-g	8.00c-e	12.25cd	23.50b-e	1.88c-f	3.38d-g	5.45c-e	8.80d-f	4.50bc	0.75bc	5.25bc	0.25bc	0.16cd	0.47bc
C + S20	4.25e-g	5.50de	8.00d	17.25c-e	1.28ef	2.53g	4.15de	5.88f	2.75bc	0.25bc	3.00bc	0.18c	0.04d	0.23c

Means in a column followed by the same letter are not significantly different according to DMRT (P = 0.05). A=Atrazine, M=Atrazine + Nicosulfuron, C=Herbicide-free soil, S5% = 5% sawdust, S10% = 10% sawdust, S15% = 15% sawdust, S20% = 20% sawdust, C+S0 = Untreated soil

Weed Flora Composition As Influenced By Sugarcane Genotypes, Trash Mulch And Weed Control Measures

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ABSTRACT: This study was conducted to evaluate weed species composition based on observation and changes in response to trash mulch and weed control measures in two sugarcane genotypes in 2016 and 2017. The treatments are two sugarcane genotypes (Bida local and NCS 001), four sugarcane trash mulch levels (0, 3, 6, 9 t ha^{-1}) and four weed control measures (weedy check, 5 monthly hoe weeding (5 MHW), pre-emergence (PE) application of diuron at 2 kg a.i ha^{-1} + Post-Emergence (POE) of 3-maize force at 179.2 g ha^{-1} + two hoe weeding (2 HW)] and PE diuron + POE 3-maize force arranged in a split plot design and replicated three times. Weed control measures and trash mulch constitute the main plot while sugarcane genotypes constitute the subplot. Based on the importance value, the results indicated that *Paspalum scrobiculatum* (L.), *Brachiaria deflexa* (Schumach) C.E Hubb. exRobyns, *Eleusine indica* (L.) Gaertn, *Brachiaria jubata* (Fig & De Not.)Sosef, *Seteria barbata* (Lam.)Kunth, *Dactylactenum aegyptium* (L.) Wild, *Digitaria milangina* (Rendle)Stapf), *Kyllinga squamulata* (Vahl), *Phyllanthus niruri* (L.), *Commelina. Benghalensis* (L.), *Corchorus olitorius* (L.), *Hyptis suaveolens* (L.) Poit, *Digitaria nuda* (Schumach.) and *Cyperus esculentus* (L.) were the most important weeds in sugarcane (Bida local and NCS 001) genotypes in both years. In conclusion, the most notable weeds associated with the sugarcane genotypes were grasses followed by sedges families. Weed control methods in sugarcane should be made towards the control of grasses and sedges species.

Keywords: Genotype, sugarcane, trash mulch, weed flora, weed management

INTRODUCTION:

Sugarcane accounts for about 75 % of the world's sucrose production (Da Silva and Bressiani, 2005). Besides the production of raw sugar, of which sugarcane is mainly produced for, sugarcane also represents an important supply of renewable energy which has recently gained attention because of ethanol production (Smeets and Lewandowski, 2009). Weeds pose tough competition to sugarcane crop because of wide spacing, slow germination and initial growth, heavy fertilization and frequent irrigations (Refsell and Hartzler, 2009).. Crop- weed competition in sugarcane is enhanced by the Initial slow growth and wider row spacing between ridges. Apart from the quantitative damages caused by weeds, they also cause a reduction in crop yield. In order to determine the yield losses of sugarcane in relation to weed species and their density, the weed species abundance should be documented. This information will be useful in determining the occurrence and relative importance of weed species in sugarcane crop production system (Firehun, and Tamado, 2007).. It is therefore imperative that if the weed population and their reproduction characteristic are known, this information could be used to guide farmers and estate producer's options in integrated management systems (Akobundu *et al.,* 2016),. No such information is available from this area. Hence, the aim of the research were; to determine the phytosociological characters of weeds, and to identify the most important weeds associated with sugarcane crop in this area

MATERIALS AND METHODS:

The upland sugarcane experimental field located at the National Cereals Research Institute, Badeggi (lat. 9^0 45′N, long. 06^0 07′ E) was used as the experimental site in 2016 and 2017 rainy season. The total rainfall during the experimental period was 1504.1 mm in 2016 and 1045.4 mm in 2017, respectively. The mean air temperature during the sugarcane plant cropping season was 35 to 38°C in 2016 and 34 to 36°C in 2017 plant cropping seasons. The experiment was initiated in the month of February in 2016 and 2017, respectively. The vegetative cover of the experimental site was manually cleared, ploughed and harrowed with a tractor before cultivation. Healthy stalks of sugarcane were used as planting material. The planting material were cut into setts each containing three eye buds and laid horizontally end to end per row. The PE diuron was applied within twenty four after planting at the rate of 2.0 kg a.i/ha while the POE metolachlor was applied at five weeks after planting (WAP) at a rate of 179.2g a.i/ha. The identification of weeds was observed using the handbook of West African Weeds [6]. Basal application of 120 kg ha^{-1} N fertilizer as urea, 60 kg P ha^{-1} as single superphosphate and 90 kg K ha^{-1} as muriate of potash were split – applied. Half was applied at planting while the remaining was applied at 8-10 WAP during the earthing up in form of band placement. Fertilizers application was carried out by side banding at about 5 cm away from the seedlings and at about 5 cm deep along the ridge. The treatments consisted of two sugarcane genotypes, Chewing cane (Bida local) and Industrial cane(NCS 001), four cane trash mulching levels, (0, 3, 6, 9 t ha^{-1}) and four weed control measures [(weedy check, 5 monthly hoe weeding (5MHW), Pre-emergence of Diuron at 2 kg a.i/ha (PE) + Post-Emergence(POE) metolachlor at 179.2 g/ha + Two hoe weeding (2 HW) and PE diuron + metolachlor] arranged as a split plot and replicated three times. Herbicides application was done using knapsack (CP3) sprayer at a spray volume of 4l/ha. The main plot consisted of weed control measures and trash mulching, while sugarcane genotypes were allocated to the subplot. The gross plot size was 35 m^2 (7 m x 5 m), while the net plot size was 17.5 m^2 (3.5 m x 5 m). Each net plot consists of four rows of 5 m long.. Weed samples were collected from a (1 x 1 m^2) quadrat placed discreetly in each plot at 9 months after planting (MAP). A total of 96 sugarcane planted plots were sampled. Weed seedlings in each quadrat were pulled out, counted and separated by species. The weeds were observed using the handbook of West African Weeds (Akobundu *et al*., 2016). Irrespective of trash mulch and weed control measures, the weed phytosociological parameters collected in the two sugarcane genotypes were frequency, density, dominance, and their relative values and importance value index. The composition of the weed species was analyzed using the importance Value Index (IVI) of each species within each plot as follows:

Importance Value Index (IVI) = [Relative frequency (RF) + Relative density (R. Dn.) + Relative dominance (R. Do.) (Ramirez and Plaza, 2015)

Where

Relative frequency (RF) = $\frac{Number\ of\ occurrence\ of\ a\ species}{Sum\ of\ occurence\ of\ all\ species} \times 100$

Relative density (R. Dn.) = $\frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ individuals\ of\ all\ the\ species\ in\ all\ quadrats} \times 100$

Relative dominance (R. Do.) = $\frac{Abundance\ of\ a\ species}{Sum\ of\ abundance\ of\ all\ species} \times 100$

$= \frac{A}{\sum Ai} \times 100$

Where 'A' is the abundance of a species and '($\sum Ai$)' is the sum of abundance of all species

RESULTS AND DISCUSSION

In terms of relative frequency, a total of 46 weed species were identified across the fields of sugarcane genotypes (Table 1). The most frequent weed species in NCS 001 with relative frequency above 10 % were *P. scrobiculatum* and *E. indica* (L.) in 2016, and *C. dactylon* (Linn.) and *H. suaveolens* (Poit.) in 2017. On the other hand, in Bida local, the most frequent weed species were *P. scrobiculatum* and *E. indica* (L.) in 2016. However, in 2017, *C. dactylon* Linn. and *H. suaveolens* Poit were observed. The outcome of this study shows that the high frequency of this species is an indication of their importance as troublesome weeds of sugarcane. This could be attributed to adaptability to the local conditions and compete efficiently with the sugarcane crops. In a previous study, Blanco (2014) stated that weed species may exhibit high frequencies only in environments that they are adapted to irrespective of the disturbances in the ecological conditions of the site.

Table 1: Weed species composition and their relative frequency under two sugarcane varieties at 9 MAP

			Relative frequency			
			NCS 001		Bida local	
Weed species	LC	MG	2016	2017	2016	2017
***Paspalum scrobiculatum* (Linn.)**	P	G	12.37	4.0	13.89	3.53
***Setaria pumila* (Poir) Roem & Schult**	A	G	1.03	-	2.39	-
***Cynadon dactylon* (Linn.) Pers.**	P	S	2.06	10.89	1.15	10.59
***Phyllanthus niruri* (Schum.&Thonn) Learndri**	A	S	-	4.0	-	5.88
***Commelina diffusa* (Burm.f.)**	P	S	-	-	5.85	-
***Kyllinga squamulata* (Thorn.ex Vahl)**	A	S	8.25	-	6.89	-
***Eragrostis tremula* (Hochst.ex.Steud)**	A	G	-	-	2.39	-
***Sacciolepis Africana* (Hubb. & Snowden)**	P	G	3.09	-	2.39	-
***Panicum laxum* Sw.**	A	G	2.06	-	1.15	-
***Brachiaria deflexa* (Schumach) C.E Hubbard ex Robyns**	A	G	5.16	2.97	4.59	3.53
***Euphorbia hirta* (Linn.)**	A	B	-	-	3.55	-
***Digitaria horizontalis* (Willd.)**	A	G	4.02	-	8.06	-
***Tridax procumbens* (Linn.)**	A	B	2.06	-	1.15	1.18
***Eleusine indica* (L) Gaertn.**	A	G	11.34	-	10.35	-
***Ludwigia hyssopifolia* (G.Don) Exell**	A	B	3.09	-	-	-
***Brachiaria jubata* (Fig & De Not.) Stapt**	A	G	5.16	-	6.89	-
***Cyperus esculentus* (Linn.)**	P	S	4.02	8.91	4.59	8.24
***Seteria barbata* (Lasr.) Kunth**	A	G	3.09	-	1.15	-
***Imperata cylindrical* (Linn.) Raeuschel**	P	G	2.06	0.99	3.55	2.35
***Commelina benghalensis* (L.)**	P	B	5.16	9.90	-	8.24
***Trianthema portulacastrum* (Linn.)**	A	B	1.03	-	1.15	-
***Tephrosia bracteolate* (Guill & Perr.)**	A	B	2.06	-	1.15	-

***Dactylactenum aegyptium* (Linn.)**	A	G	5.16	9.90	3.55	9.41
***Setaria longiseta* (P.Beauv.)**	A	G	-	-	2.39	-
***Corchorus olitorius* (L.)**	A	B	1.03	6.93	1.15	8.24
***Rottboellia cochinchinensis* (Lour.) Clayton**	A	G	1.03	2.0	-	1.17
***Cleome hirta* (L.)**	A	B	2.06	-	1.15	-
***Chloris pilosa* (Schumach)**	A	G	1.03	-	-	-
***Setaria verticilillata* (Lam.) Kunth**	A	G	2.06	-	1.15	-
***Cyperus rotundus* (Linn.)**	P	S	1.03	-	1.15	-
***Cleome viscose* (L.)**	A	B	2.06	-	2.39	-
***Digitaria milangina* (Wild.)**	A	G	4.02	-	1.15	-
***Desmodium tortuosum* (Sw.) DC.**	A	B	-	-	1.15	-
***Sesamum alatum* (Thonning)**	A	B	-	-	-	1.18
***Gomphrena celosiodes* (Mart.)**	A	B	-	0.99	-	-
***Ipomoea asarifolia* (Desr.) Roem & Schult**	P	B	-	-	1.15	-
***Hyptis suaveolens* (Poit)**	A	B	2.06	12.87	1.15	15.19
***Andropogon gayanus* (Schum.& Thonn)**	P	G	1.03	-	1.15	-
***Digitaria nuda* (Schumach.)**	A	G	-	5.0	-	5.88
***Boerhavia diffusa* (L.)**	A	B	-	2.0	-	2.35
***Physalis angulata* (Linn.)**	A	B	-	2.97	-	-
***Schwenckia Americana* (L.)**	P	B	-	2.0	-	3.53
***Sebastiana chamaelea* (L.) Muell.Arg.**	P	B	-	8.91	-	7.06
***Tephrosia linearis* (Wild.) Pers.**	A	B	-	2.97	-	1.18
***Calopogonium mucunoides* (Desv.)**	P	B	-	-	-	1.18
***Leucas martinicensis* (Jacq.) Ait.f.**	A	B	-	2.0	-	-

LC-Life cycle, MG- Morphological group

Furthermore, the phytosociological study shows that nine species were most dominant in 2016 in both genotypes (Table 2) namely *P. scrobiculatum, B. deflexa, E. indica, B. jubata, S. barbata, D. aegyptium, D. milangina, K. squamulata and C. esculentus*. In 2017, the weed species with highest important value index in both genotypes were *P. niruri, B. deflexa, C. esculentus, C. benghalensis, D. aegyptium, C. olitorius, H. suaveolens, D. nuda, B. diffusa, S. chamaelea* with *P. scrobiculatum* and *C. dactylon* in NCS 001 genotype only and *C. diffusa* in Bida local only. The high important value of these species indicated their dominance and ecological success was due to their high phenotypic plasticity, more competitive characteristics such as large production of seeds, alternating forms of propagation and a high capacity of spread. Similar observation were made by Blanco (2014).

Table 2: Weed species composition and their relative density under two sugarcane varieties at 9 MAP

			Relative density			
			NCS 001		Bida local	
Weed species	LC	MG	2016	2017	2016	2017
***Paspalum scrobiculatum* (Linn.)**	P	G	22.27	2.89	20.83	1.13
***Setaria pumila* (Poir) Roem & Schult**	A	G	0.80	-	5.25	-
***Cynadon dactylon* (Linn.) Pers.**	P	S	0.37	15.96	0.49	21.09
***Phyllanthus niruri* (Schum.& Thonn) Learndri**	A	S	-	7.23	-	2.89
***Commelina diffusa* (Burm.f.)**	P	S	-	-	1.35	-

***Kyllinga squamulata* (Thorn.ex Vahl)**	A	S	19.99	-	19.73	-
***Eragrostis tremula* (Hochst.ex.Steud)**	A	G	-	-	1.35	-
***Sacciolepis Africana* (Hubb & Snowden)**	P	G	1.79	-	1.59	-
***Panicum laxum* Sw.**	A	G	1.67	-	0.67	-
***Brachiaria deflexa* (Schumach) C.E Hubbard ex Robyns**	A	G	11.73	3.57	5.76	4.67
***Euphorbia hirta* (Linn.)**	A	B	-	-	0.43	-
***Digitaria horizontalis* (Willd.)**	A	G	1.48	-	8.89	-
***Tridax procumbens* (Linn.)**	A	B	0.31	-	0.18	0.16
***Eleusine indica*(L) Gaertn.**	A	G	9.49	-	9.29	-
***Ludwigia hyssopifolia* (G.Don) Exell**	A	B	0.25	-	-	-
***Brachiaria jubata* (Fig & De Not.) Stapt**	A	G	7.04	-	4.29	-
***Cyperus esculentus* (Linn.)**	P	S	1.67	5.60	3.37	9.18
***Seteria barbata* (Lasr.) Kunth**	A	G	5.38	-	2.61	-
***Imperata cylindrical* (Linn.) Raeuschel**	P	G	1.36	0.51	1.35	2.09
***Commelina benghalensis* (L.)**	P	B	1.60	3.74	-	7.09
***Trianthema portulacastrum* (Linn.)**	A	B	0.12	-	0.55	-
***Tephrosia bracteolate* (Guill & Perr.)**	A	B	0.25	-	0.06	-

LC-Life cycle, MG- Morphological group

CONCLUSION

This study was able to establish that the most important weeds that were associated with sugarcane genotypes in this trial were mostly grasses, a few broadleaved and sedges. The weed species of importance in sugarcane in both seasons were *P. scrobiculatum*, *B. deflexa*, *E. indica*, *B. jubata*, *S. barbata*, *D. aegyptium*, *D. milangina*, *K. squamulata* and *C. esculentus*. The weed species with high IVI in sugarcane suggest their adaptation and ability to produce high amount of seeds in the soil bank. Effective weed management strategy should focus on the control of growth and reproduction of the grass and sedge weed species infestation.

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Effects of Storage Type and Humidity on Germination and Mycoflora Population of Soybean (*Glycine max* L.) Seeds

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ABSTRACT

Seed-borne pathogens are responsible for seed rot in soybeans, resulting in poor germination and seedling mortality, leading to low productivity. Thus, the present study investigated the effects of storage types and seed disinfection period on seed germination and seed-borne fungi of soybean. Seed samples were tested for seed-borne fungi using the blotter and agar plate method after treatment with three disinfection periods (0, 3 and 6 minutes) and under two storage environments; cold storage and warehouse. Fungi were identified based on colony morphology and microscopic characteristics. Germination percentage and seedling vigour were also determined. A total of seven fungi species; *Aspergillus flavus, A. fumigatus, A. niger, Fusarium spp.*, *Penicillium* sp., *Rhizopus* sp., *and Curvularia* sp. were isolated from the soybean seeds, irrespective of the storage type and disinfection time. *Fusarium* and *Curvularia* species were not isolated by the blotter method. The seed disinfection period showed a significant effect ($p>0.05$) on the percentage incidence of fungal infection. *Aspergillus flavus* had the highest percentage occurrence, with 32.8% and 29.5% from the blotter and agar plate method, respectively, in 0-minute seed lots, while *Penicillium* species had the least occurrence in both storage types, with 12.9% and 15.67% on the blotter and agar plate method, respectively, in the plate disinfected for 6 minutes. The study showed that surface disinfection period and storage methods considerably affect fungal infection and quality of soybean seed. Therefore, seed-borne fungi can be reduced by seed treatment and better storage conditions.

Keywords: Soybean, Agar, Blotter Test, Fungi, Seed-borne, Storage Type

INTRODUCTION

Soybeans are the world's leading legume among oil seed crops (Sanginga *et al.*, 2002). It is a vegetable protein oilseed extensively grown in the tropical, sub-tropical, and temperate regions (Soybean Encyclopedia, 2022). The plant is classified as an oilseed rather than a pulse by the UN Food and Agriculture Organization (FAO). The cultivation of the crop is increasing in Nigeria as a result of its importance as a cash crop used in the food and feed industry (Sanginga *et al.*, 2002; Ugbabe *et al.*, 2017). Nigeria is the second largest producer of soybeans in Africa after South Africa, producing 630,000 Mt in 2019 (FAOSTAT, 2019).

Optimum soybean cultivation is hindered by lack of good quality seed (Amin *et al.*, 2009; Rahman *et al.*, 2013). Seed-borne pathogens cause losses in soybeans both in seed quality and quantity. The microflora reduces seed germination and seedling vigour index of the crop and can be a vehicle for plant pathogenic agents that are known to be responsible for seed rot, abortion, deformation, seedling blight, bacterial pustules, root/stem rot, as well as pod blight diseases (Carvalho and Nakagawa, 2012; Bandara *et al.*, 2020; Roth *et al.*, 2020).

Several factors affect the quality of stored seeds and predispose them to infection. These factors include the moisture content, nature or type of packaging materials, temperature, relative humidity, and chemical composition of the seeds (Santos *et al.*, 2016). At maturity, harvesting stages and or in storage, the seeds get exposed to fluctuations in humidity and temperature, and hence develop several kinds of moulds which result to seed spoilage (Arya and Monaco, 2007). Poor storage conditions greatly affect seed vigour (Wawrzyniak *et al.*, 2020), reduce respiration and seedling size. Therefore, maintaining seed quality during storage is essential in soybean production chain. To increase the production of soybean qualitatively and quantitatively, farmers require healthy seeds with a high percentage of germination and purity, because fields planted with high-vigour seeds yield higher (Bagateli *et al.*, 2019). Thus, the present study investigated the effects of storage type and seed disinfection period on germination and seed-borne fungi in soybean.

MATERIALS AND METHODS

Samples Collection

Soybean seed (TGX 1448-2E) used for this experiment was obtained from the Soybean Programme of the National Cereals Research Institute, Badeggi, Nigeria. The seed samples were brought to the laboratory and stored at room temperature for subsequent studies.

Experimental Design and Treatment

The seed samples were divided into three and separately disinfected in 1% aqueous solution of sodium hypochlorite for 0, 3 and 6 minutes. This was followed by rinsing in three changes of sterile distilled water and drying between two layers of soft tissue paper at two storage environments; cold storage (CS) and warehouse (WH). The experiment was laid out in a completely randomized design with three replications.

Detection and Identification of Fungi

The seed-borne fungi in the seed samples were detected and enumerated by the blotter method and the agar plate method.

Blotter Technique

Three pieces of filter paper were soaked in sterilized distilled water and placed at the bottom of a 9 cm diameter Petri dish. Soybean seed samples from each treatment were taken randomly and placed on the filter paper at the rate of 10 seeds per Petri dish and incubated at 25^{o} C for seven days. After incubation, the seeds were examined under a microscope to record the seed-borne fungal infection observed on the incubated seeds.

Agar Plating Technique

Ten soybean seeds samples from each treatment were placed in a Petri dish containing potato dextrose agar (PDA) and incubated for seven days at 25°C. The fungal pathogens associated with the seeds was identified following sporulation.

Fungal Identification

Pure cultures of individual fungal isolates were critically examined and identified. Fungi were identified based on colony morphology and microscopic characteristics. Colony identification was based on characteristics such as colour, texture, and type of pigmentation. Microscopic characteristics of spores such as shape and colour were also used to identify the pathogens associated with the seeds. Percentage seed infection was calculated as the proportion of soybean seeds showing symptom of infection and the total number of seeds used, expressed as a percentage.

Seed Viability Test

The standard germination test was used to evaluate seed viability. One hundred (100) seeds per treatment, per replication, were placed on filter paper moistened with water and placed inside a growth chamber for 7 days. Percentage seed viability / germination was calculated as the proportion of viable seeds and the total number of seeds used, expressed in percentage.

Seed Vigour Test

Seed vigour was evaluated using the accelerated aging (AA) test according to the formula, Seed vigour = (Mean root length+ Mean shoot length) × Germination (%).

Statistical Analysis

Data on type and frequency of occurrence of identified fungal species were recorded. The percentage of seed infection and percentage seed germination were subjected to analysis of variance (ANOVA) using SAS software. The mean was compared using the Least Significant Difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

A total of seven fungi species in five genera (*Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Fusarium* spp., *Penicillium* sp., *Rhizopus* sp., *and Curvularia* sp.) were isolated from the seed samples, irrespective of the storage method used (Table 1). These fungi have been reported to be seed-borne in soybean by previous researchers (Shovan *et al.*, 2008; Lević *et al.*, 2012). All the species were isolated by the agar plate method, except *Fusarium* and *Curvularia* spp, both of which were isolated by the blotter method. This is because PDA is more sensitive in detecting even traces of infection. This is corroborated by the findings of Shovan *et al.* (2008) and Seweta *et al.* (2011) who reported that the percentage of mycoflora isolated by the agar plate was higher than blotter method in soybean. This study also indicated that time of seed disinfection has a significant difference ($P > 0.05$) on the percentage of fungi isolation and seed infection. *Aspergillus flavus* had the highest percentage of occurrence (48.8% and 29.5% on blotter and agar plate, respectively), in a 0-minute seed treatment, while *Penicillium* spp had the least percentage of occurrences, with 12.9% and 10.8% on blotter method and agar plate, respectively, in 6 minutes. Similar results have been reported on groundnut seed by Rasheed *et al.* (2004). Tariq *et al*. (2005) also concluded that A. *flavus* and *A. niger* were the predominant storage fungi of soybean seed. These species have been reported to reduce seed germination, damage seeds in storage and produce mycotoxins. The highest seed infection (100%) was observed in the control treatment i.e. seed without disinfection, while the lowest seed infection (32.0%) was recorded in the plate containing disinfected seeds with a longer time of disinfection (6 minutes), indicating that disinfection time has a significant effect on fungal pathogens associated with the seeds. Dawar *et al*. (2007) reported that surface disinfection reduces external fungal contamination while disinfection time has no significant effect on germination potential and seedling vigour. Storage environments had a significant effect ($P > 0.05$) on seed viability and vigour. From this study, there was a significant difference in seed vigour of 83% in CS compared to 52% in WH. The decrease can be attributed to fluctuation in relative humidity of the WH. De Vries *et al.* (2007) and Vieira *et al.* (2001) opined that seed viability is intricately linked to seed moisture content, which in turn, depends on the relative humidity of the storage environment.

CONCLUSION

Storage method and surface disinfection period affect fungal infection and quality of soybean seeds. These factors are crucial for seed survival in storage. There is a need to reduce the pathogenic fungi by seed disinfection and the use of cold storage medium, so as to reduce mycotoxins produced by these fungi on soybean seeds. It is recommended that further work on different storage methods be conducted to identify other major pathogenic fungi associated with seeds of other soybean varieties so as to develop a comprehensive integrated control measure for reducing losses due to seed-borne fungi.

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Table 1: Percentage Occurrence of Fungi Isolated from Treated and Untreated Soybean Seeds with Different Isolation Methods

	Disinfection time @ 0-min.		**Disinfection time @ 6-min.**	
Fungi isolates	**Agar plate**	**Blotter plate**	**Agar plate**	**Blotter plate**
Aspergillus flavus	29.5	48.8	16.0	23.2
A. niger	10.0	10.3	14.0	22.7
A. fumigatus	11.6	12.2	16.2	18.3
***Fusarium* spp**	15.0	-	14.5	-
***Penicillium* sp**	11.5	15.0	10.8	12.9
***Rhizopus* sp**	10.4	13.7	14.0	22.9
***Curvularia* sp**	12.0	-	14.5	-

Growth And Yield Attributes Of Newly Registered Ginger Cultivars Evaluated Under The Savannah Transition Agro-Ecology

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ABSTRACT
Understanding the performance of cultivars in area of production is key to increasing productivity in farmers' fields. In order to assess the growth and rhizome attributes of the two newly registered ginger and local cultivars under the savannah transition agro-ecology, a field trial was conducted at the National Root Crops Research Institute, Iresi Out-station experimental field in Osun state in the 2021 cropping season. The experiment was laid out in a Randomized Complete Block Design with three replicates. Analysis of variance showed significant ($p < 0.05$) differences among the three cultivars for all the growth and yield attributes except plant height. Cultivar UG1 and UG2 had higher number of tillers, number of leaves and leaf area index compared to the local (check) cultivar, while leaf area for local cultivar was higher than the registered cultivars. UG1(yellow) and UG2 with rhizome yield of 35.11 t/ ha and 33.67t/ha, respectively were superior to the 18.16t/ha of the local cultivar. While plant height had no significant ($p>0.05$) relationship with rhizome yield, all other attributes (except LA with correlation coefficient (r) = -0.92), showed strong and positive relationship with rhizome yield with their various 'r' ranging between 0.79 and 0.89. The superior performance of the two newly registered ginger cultivars above the local one gives farmers in the savannah transition agro-ecology sustainable means of increasing their ginger productivity.

Keywords: Rhizome yield, morphological traits and correlation rhizome yield-morphological traits

INTRODUCTION
Ginger (*Zingiber officcinale* Roscoe) is an important spice in the family *Zingiberaceae* with 90 species (Kizhakkayil and Bhas, 2011). Ginger plant is refreshingly aromatic but it is the rhizome (raw or processed) that is valued as a spice (Mary et.al, 2021). As a spice, it is high valued and export-oriented, and plays an important role in the agricultural economy of the countries that grow them, supporting the livelihood and improving the economic level of many ginger growers (Sodangi, 2020). Nigeria, with production figure of 160,000 metric tons, is the 4th highest ginger producing country with India (702,000 metric tons), China (388,886 metric tons) and Nepal (216,289 metric tons) being the first three countries (FAOSTAT, 2014).

Although Nigeria is the largest producer and exporter of ginger in Africa, the level of production is generally low compared to other export crops, while productivity has remained abysmal due to several factors which include poor soil fertility, shortage of improved cultivars, poor agronomic practices and effects of pests and diseases (Hailemichael and Tesfaye, 2008; MOARD, 2007; Amadi et al., 2010). Majority of Nigeria's ginger production comes from the southern part of Kaduna State with average yield 2-5t/ha which is far below actual yield of the crop under improve cultivation (Sodangi,2020). Ginger is also grown in South-west Nigeria. As one of the major shortcomings of ginger production in Nigeria is lack of improved cultivars of ginger which resulted to low yield. The National Root Crops Research Institute, Umudike, through its ginger breeding program, developed and registered two ginger cultivars which have been tested in many locations. The results presented in this paper were from the evaluation of the new cultivars under the savannah transition agro-ecology.

MATERIALS AND METHODS;

The study was conducted at the research field of National Root Crops Research Institute, Iresi out-station (Longitude 7.94^0 N, Latitude 4.84^0 E and Altitude 494m above sea level) in Osun state in the savannah transition agro-ecology of South-west Nigeria during the 2021 cropping season. Treatments comprising of three ginger varieties (UG1, UG2 and local cultivar) were laid out in a randomized complete block design with three replicates. The field was cleared, ploughed and harrowed. The ginger setts or rhizomes weighing 10 g of each cultivar were planted on a bed plot measuring 2 m x 3 m and raised to 0.5 m crest with inter- and intra -row spacing of 0.2 m x 0.2 m giving plant population density of 250,000/ha. Each rhizome was planted 7 cm beneath the soil with the growth buds facing up so that the shoots can grow towards the surface. Mulching was carried out immediately after planting using a mixture of *Chromolaena odorata* (L.) commonly called siam weed and grass materials found in the area at the rate of 3.5t/ha. Poultry manure was applied and worked into the soil before planting at the rate of 20 t/ha. Weeds were manually controlled at 6 and 10 weeks after planting. Data were collected on the following growth parameters at 4, 6, 8, 10, 12, 14 and 16 weeks after planting; establishment count, plant height, number of tillers, leaf number, leaf area (using leaf length and width x 0.6475 according to Kandiannan et.al, 2009 and leaf area index. Rhizome yield per plot were estimated at harvest. All the data collected were subjected to analyses of variance (ANOVA) using the generalized linear model procedure of the System Analyses Software (SAS, 1992 version). The treatment means were separated using fisher's LSD at 5% of probability.

RESULTS AND DISCUSSION

Table 1 shows the performances of the two registered and one local ginger cultivars evaluated for plant height (cm), number of tillers, number of leaves, leaf area, leaf area index and rhizome yield. All the measured cultivar growth and yield attributes showed significant differences ($p<0.05$) among the cultivars except in plant height where all the cultivars were statistically the same with a range of 96.33 – 106.00 cm. Chukwudi et al. (2020) and Sodangi (2020) reported same findings in their studies, except that while they both found plant height to be significantly different, Sodangi (2020) also reported no cultivar variation for number of tillers per plant and number of leaves per shoot. For all the attributes (except in leaf area (LA) where the local cultivar had higher LA), the registered cultivars showed marked superiority against the local cultivar. This is unexpected as the registered cultivars have passed through some selection process. The rhizome yields of the two registered ginger cultivars (UG1 = 35.11 and UG2 = 33.67 t/ha) almost doubled that of the local cultivar (18.16 t/ha).

Table 2 shows the relationships between rhizome yield and other measured attributes. Plant height had no significant ($p>0.05$) relationship with rhizome yield. However, all other attributes (except LA with correlation coefficient (r) = -0.92), showed strong and positive relationship with rhizome yield with their various 'r' ranging between 0.79 and 0.89. These results were similar to the findings of Islam et al. (2008) who reported positive and significant relationship between rhizome yield and number of tillers per plant, plant height and leaf area attributes. The strong and positive 'r' suggests that rhizome yield tends to increase as the values of these attributes increase, which explains the huge yield differential between the registered cultivars and the local cultivar as the registered cultivars had significantly higher values for the important growth traits. The strong genotypic correlation between these traits and rhizome yield reported by Islam et al. (2008) further suggests that the observed relationship has genetic background.

The superior performances of the registered cultivars, especially in rhizome yield will lead to increased productivity in farmers' fields. With such a good performance of these cultivars in the transition savannah ecology of the south-west Nigeria outside ginger's known cultivation hub of southern Kaduna and the entire guinea savannah that controls over 80% of ginger production in Nigeria ((Sodangi, 2020), ginger's agroecological production zones in Nigeria will further increase (Amadi,2012).

Table1: Rhizome yield and other attributes of newly registered ginger cultivars evaluated in the Savannah transition agroecology of Iresi, Osun state in 2021.

Cultivars	Plant height (cm)	Number of tillers	Number of leaves	Leaf area (m^2)	Leaf area index	Rhizome yield (t/ha)	Flesh colour
UG1	96.33^{a}	8.44^{a}	22.39^{a}	0.01^{b}	0.010^{a}	35.11^{a}	Yellow
UG2	103.06^{a}	8.89^{a}	20.39^{a}	0.01^{b}	0.009^{ab}	33.67^{a}	Black
Local (check)	106.00^{a}	3.00^{b}	7.39^{b}	0.05^{a}	0.007^{b}	18.16^{b}	White
Mean	101.79	6.78	16.72	0.02	0.01	28.98	
$LSD_{0.05}$	12.12^{ns}	4.81	2.44	0.007	0.002	3.91	
R-square	0.75	0.80	0.99	0.99	0.75	0.98	

Mean followed by the same letter(s) are not significantly different at $p<0.05$

Table 2: Correlation coefficients Relationship between yield and morphological traits of ginger cultivars evaluated under the savannah transition ecology of Osun state.

Plant height(cm)	Number of tillers	Number of leaves	Leaf area (m^2)	Leaf area index	Rhizome yield (t/ha)
Plant height (cm)	-0.032^{ns}	-0.459^{ns}	0.416^{ns}	-0.134^{ns}	-0.223^{ns}
Number of tillers	---	0.784*	0.801**	0.716*	0.795**
Number of leaves		---	0.967***	0.865**	0.894**
Leaf area (m^2)			---	-0.766*	-0.921**
Leaf area index				---	0.795*

CONCLUSION

The evaluation of the newly registered ginger cultivars in the savannah transition ecology of the south-west Nigeria and the superior performance of these new cultivars over the local cultivar will help increase the agro-ecologies that can produce ginger in Nigeria, and further increase productivity in farmers' fields. The findings about the relationships that exist between rhizome yield and other growth attributes has further enhanced the knowledge on how to improve the crop's breeding.

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Different Liquid Organic Fertilizers And Their Effects On Growth And Yeild Of Turmeric Rhizome In Umudilke

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ABSTRACT

Experiment was carried out at National Root Crops Research Institute Umudike research farm, to evaluate the effect of different liquid organic fertilizers on selected growth parameters and yield of fresh Turmeric rhizome. The treatments comprises of four liquid organic fertilizers (Boast Extra, Black Diamond, Super-Gro and Pro-Plant) and control, given a total of 5 treatments. The experiment was laid out on manually prepared seed beds of 3 m X 2 m, arranged in RCBD and replicated 3 times.Pre-cropping soil sample was collected at the depth of 0-30cm, air dried, processed and analyzed in the laboratory using standard soil analytical methods.Liquid fertilizers were diluted (100 mls in 10 liters of distilled water) and applied on turmeric leaves using hand sprayer one month after planting. Growth data were collected at 2, 3, 4, 5 and 6 months after planting. While yield data were collected at harvest (7 months after planting). Data collected were subjected to ANOVA, while significant means were separated using LSD at 5% probability level. Result from the study showed that different liquid organic fertilizers significantly improved selected growth component tested. Plant height increased from 60 – 135 cm, number of tiller increased from 3 – 8 numbers. Turmeric yield also increased across the treated plots, with plots treated with Boast Extra given highest yield of 20.03 t/ha followed by 18.67and 17.93 t/ha from Super-Gro and Black Diamond respectively. This study has shown that application of different liquid organic fertilizers can improve Turmeric growth and yield while serving as an alternative to expensive inorganic fertilizer for poor resource farmers in Umudike.

Key words: liquid, organic fertilizer, turmeric

INTRODUCTION

Application of organic fertilizer as a component of sustainable agriculture apart from soil mineral provision, contributes to soil quality by improving the structure,chemistry and biological levels of soil. They have an advantage of gradual release of nutrients and reusing soil organic matter content (Ukoje, 2012). In Nigeria and in global world deviation from inorganic to organic agriculture is becoming the content and is imperative for healthy sustainable agriculture (Obasi, 2019). The disadvantages of inorganic fertilizer are high cost and long term environmental damage which perhaps outweighed the advantages and this also affects the poverty level of Nigerians and fragility of ecosystem (Adesina, 2012).Turmeric whose active ingredients is curcumin and one of the root crops in NRCRI Umudike, requires fertilization to improve yield and productivity. Much work has not been done on organic fertilization of Turmeric and there is dearth information on the use of liquid organic fertilizers on Turmeric production. Therefore, the objective of this work is to determine the effect of different liquid organic fertilizers as foliar spray on the growth and yield of Turmeric in Umudike.

MATERIALS AND METHODS

Four different liquid organic fertilizers (Boast Extra, Black Diamond, Super-Gro and Pro-Plant) were evaluated using Turmeric (*curcuma longa*) as a test crop at the research farm of NRCRI Umudike in 2021 farming season. The experiment was laid out in a Randomized Complete Block Design (RCBD). Plot size was $6m^2$ with a plant spacing of 50cm x 30 cm, liquid fertilizers were diluted (100 mls in 10 liters of distilled water) and applied on leaves using hand sprayer. The application was done 6 weeks after planting and repeated 16 weeks (4 months) after planting, followed by other field activities like weeding. Growth parameters were collected during the growth period while the yield data was collected at harvest (7 montha after planting). Data collected were subjected to Analysis of variance (ANOVA), Mean separation was carried out using least significant difference(LSD) at $p<0.05$.

RESULT AND DISCUSSION

Result of plant height (Fig. 1) shows that growth increased profusely across the growing period of the experiment. Plant height ranged from 33 to 67 cm at 2MAP, 41.7 to 79.69 cm at 3MAP, 46 to 94 cm at 4MAP, 56 to 122 cm at 5 MAP and 60 to 135 cm at 6 MAP. Highest values of plant height were recorded on plots treated with Boast Extra, followed by Black Diamond while Pro-plant recorded lowest values among the liquid organic fertilizer tested though higher than values obtained from control plot. Number of tillers (Fig. 2) ranged from 2 to 5 at 3 MAP, 2 to 7 at 4MAP and 3 to 8 at 5MAP. Highest number of tillers were obtained from plot treated with Boast Extra followed by Super-Gro while control plot had lowest number of tillers.

The effects of the organic amendment as shown on the vegetative parameters also reflected on the yield (Table2) where highest value of fresh turmeric rhizome was obtained on plot treated with Boast Extra (20.03 t/ha) followed by Super-Gro and Black Diamond (18.67 and 17.93 t/ha) while lowest yield was recorded on control plot (6.67 t/ha). The significant ($p<0.05$) increase recorded on plots treated with Boast Extra could be attributed to the traces of inorganic content (20%) combined with organic (80%) content in Boost Extra, while Black diamond, Super-Gro and Pro-plant contains 100% organic.Consequently, this agrees with the findings of Fauzie, *et al*, (2015), who reported in their work that plants absorbs inorganic fertilizer through their leaves faster than the organic fertilizer.

CONCLUSION

Application of liquid organic fertilizers increased Turmeric yield across the treated plots, with plots treated with Boast Extra given highest yield of 20.03 t/ha followed by 18.67 and 17.93 t/ha from Super-Gro and Black Diamond respectively. This study has shown that application of different liquid organic fertilizers can improve Turmeric growth and yield while serving as an alternative to expensive inorganic fertilizer for poor resource farmers in Umudike.

Table 1: Result of Pre-Cropping Soil Sample of the Study Area

Soil properties	Value
Sand (g/kg)	758
Silt (g/kg)	083
Clay (g/kg)	159
Texture	Sandy loam
pH (H_2O)	4.9
Available phosphorus (mg/kg)	14.2
Nitrogen (%)	0.103
Organic carbon (%)	1.15
Organic matter (%)	1.98
Calcium (cmol/kg)	3.8
Magnesium (cmol/kg)	0.80
Potassium (cmol/kg)	0.221
Sodium (cmol/kg)	0.123
Exchangeable acidity (cmol/kg)	1.7
Effective Cation Exchange Capacity (cmol/kg)	6.64
Base Saturation (%)	74.45

Figure 1: Effect of different liquid organic fertilizer as foliar spray on plant height (cm) of tumeric

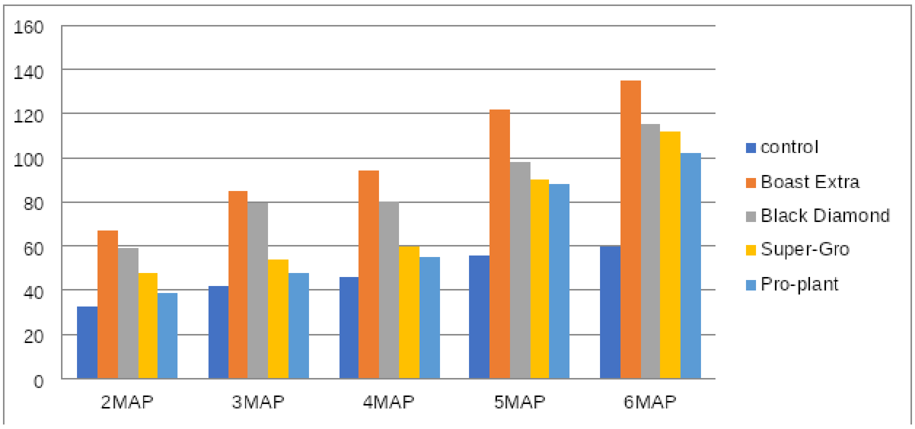

Figure 2: Effect of different liquid organic fertilizers as foliar spray on Number of Tillers

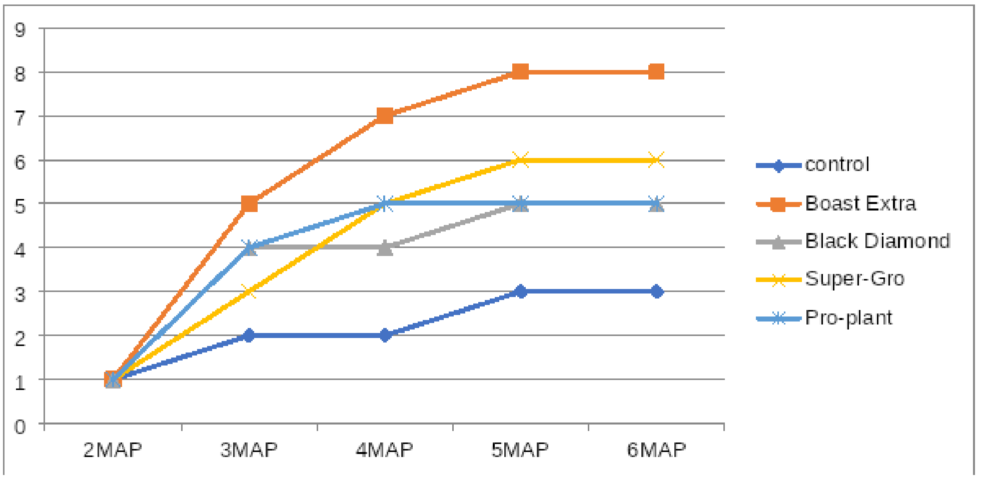

Table 2: Effect of different liquid organic fertilizer as foliar spray on fresh rhizome yield of turmeric

Treatments	**Fresh rhizome yield (t/ha)**
Control	6.67d
Black Diamond	20.03a
Boast Extra	17.93b
Super- Gro	18.67b
Pro-Plant	16.43c
Mean	**15.95**
LSD(0.05)	0.85

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Characterizing some Nigerian Yam (*Dioscorea rotundata* L.) Landraces for Resistance to Major Field Diseases and Yield in Umudike.

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ABSTRACT

Yam is one of the preferred staple foods in West Africa. Resistance to diseases and high yield potential has led to a persistent retention of these yam crops in the various environmental locations where they were collected. The variability and stability in disease resistance and yield productivity of the yams can form a strong basis for future yam breeding and selection of hybrid yams for the teaming population. The experiment was laid out in randomized complete block design involving 57 yam cultivars and three replications. Variability of 57 cultivars from *Dioscorea rotundata* were evaluated on quantitative characters such as plant sprout percentage at two months after planting, number and weight of tubers at harvest and, qualitative characters including plant vigour, yam anthracnose disease (YAD), yam mosaic disease (YMV), nematode and oxidation. Results of the work showed that all the yam cultivars gave good sprout at two months after planting with Okotebogba which gave a sprout percentage of 100 % which did not differ significantly (P<0.05) from popular cultivars Dan-nacha (99.4%) and Ekpe (98.9%). The plant vigour of the yams ranged from 1.7 to 3.3 on a scale of 1-5. The cultivar, Amola gave the highest yield of 31 t/ha which did not differ significantly from the yield of many of the yams cultivars evaluated, although some yams gave yields as low as 13.0t/ha as observed in Okpambe. Approximately 79% of the yam cultivars were tolerant to YMV, 70.1% were highly resistant YAD and 96.5% were highly resistant to nematode which are the major diseases of *D. rotundata* that they were evaluated. The oxidation of the yams ranged from slight oxidation to none oxidation. These qualities of the yams may be the reason behind the high acceptability of the yams in the various environments from where they were collected,

Keywords: Yam landraces, Disease resistance, Anthracnose, Virus, Severity

INTRODUCTION

Yam (*Dioscorea* spp.) is a tuberous crop that is mostly grown in the African tropics, Asia and the Pacific zones. It is one of the staple food crops and therefore has great significance

(Nwachukwu *et al*., 2011, Babowale, 1994). The crop is an important source of calories for millions of farmers across the globe. They are tuber crops widely grown for food and feed. They are an important source of carbohydrates and calories in many parts of the tropics and also serve as a valuable cash and subsistence crop. The world's most important multipurpose yam is *Dioscorea rotundata*, often referred to simply as the common yam, white guinea yam or round yam, which accounts for up to 80% of all global yam production and is grown in more than 60 countries.

The crop requires improvement in breeding to develop new seeds that are potentially superior to the already existing yams across the locations. This can be achieved through characterization and evaluation of landraces that have been with farmers and growers over time. The landraces have been important sources of quality genes for high yield, starch, disease resistance which are not known or documented. Farmers will continue to refuse adopting new improved yams from breeders if the new improved yams do not possess qualities better than their existing landraces.

There is no detailed information describing the landraces' profile beginning from their morphological expressions in the field to the point of post-harvest characteristics including the food quality and nutrient status. There is need to have a reliable, accessible, comprehensive documentation of the popular yam landraces which farmers have tenaciously refused to let go due to some inherent qualities of the landraces that are not readily found in the improve hybrids.

Information of this nature will serve as guide to producing replacement that can easily be accepted and adopted. The objective of this work was to assess the yam landraces of Nigeria to create a standard or bench mark for yam breeders' future yam breeding plan.

MATERIALS AND METHODS

Yam landraces were collected from various parts of Nigeria through Africa Yam Project during the on-farm evaluations in 2017, 2018 and 2019 for characterization, profiling and documentation in NRCRI, Umudike. In 2020` cropping season, 57 yam landraces of *D. rotundata* were planted in NRCRI Umudike experimental field. The experiment was established in a randomized complete block design with three replications, each block containing 57 plots and totaling 171 plots for *D. rotundata.* The yams were planted with the standard spacing of 1 m x 1 m in each plot of 5 m x 2 m (10 m^2). Data were collected on vegetative, harvest and post-harvest performances of yams.

RESULTS

All the yam cultivars gave good sprout count percentages of above 70.0 although low sprout count percentages were obtained in some of the yam cultivars such as observed in Yandu which gave a low sprout count percentage of 67.8. The plant vigour of yam cultivars was fairly good with scores of above 3 on a scoring scale of 1 - 5 except in Chiyo and Ojuiyawo both of which scored 1.7 in plant vigour. The results from the work showed that Abi, Anasue, Anyamayuwa, Meccakusa, Okotebogba and Amola gave a yield of more than 30 t/ha while which did not significantly differ (P<0.05) from many other cultivars. The yam land races were tolerant to the yam diseases for which they were evaluated for especially yam anthracnose disease severity (YADS) and nematode. Generally, the tolerance of the yams to yam mosaic virus severity (YMVS) with some of the yams score above 2.5 on a virus scoring scale of 1 – 5. Many of the yams were white in tuber flesh colour showing none oxidation or slight oxidation. This shows that many of the yam landraces in Nigeria have great potentials in disease resistance, yield and other qualities not assessed in this work. Breeders can tap into these yam qualities for developing new yams.

CONCLUSION AND RECOMMENDATION

Many of the landraces showed high yield potentials consistently over the two years and yet they are unpopular. It is therefore recommended that Okotebogba, Sandpaper, Dan-nacha, Punch, Ikookutom, Anasue, Anyamayuwa, Igbudugadu, Yotoyo, Ekpe, Ikohaakere, Abi, Ojuiyawo, Ogine, Ogoja, Asangwu, Ifara, Oyoyo, Myiomiyo, Fakesta, Yandu, Alumaco, Chiiyo and Pouna should be included among yam landraces to be nominated for registration. This will enable those yam landraces with high quality potentials to come to lime light in Nigeria for farmers' cultivation and use.

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Table 1: Mean of profiling some Nigerian Yam (*D. rotundata*) landraces in Umudike in 2020 and 2021

S/N	Landraces	%Sprout	Plant Vigor	Yield/ha	YMVS	YADS	Nematode (S)	Oxidation
1	Abi	95.5	2.7	27.0	2.3	1.3	1.0	None
2	Afiemine	96.4	2.3	17.2	3.0	1.7	0.7	Slight
3	Agboiyo	98.2	3.0	30.5	1.7	1.7	0.7	None
4	Agemaji	87.2	2.0	20.0	2.7	2.0	1.7	None
5	Agur	78.6	3.0	28.0	3.3	1.0	0.3	None
6	Alumaco	91.5	3.0	22.0	2.7	1.0	0.7	Slight
7	Amola	86.2	3.0	31.0	1.7	2.0	0.3	Slight
8	Anasue	96.6	3.0	30.0	1.3	1.0	0.0	None
9	Angeals	70.0	3.0	24.8	3.3	1.0	0.3	None
10	Anyamayuwa	78.5	3.0	30.0	3.0	1.0	0.3	Slight
11	Asangwu	93.7	2.7	25.1	2.7	1.0	0.7	None
12	Cheiyo	95.1	1.7	15.0	2.0	2.3	0.7	None
13	Chiiyo	82.0	2.3	20.5	2.0	1.3	0.7	None
14	Dan-nacha	99.4	2.7	30.7	3.0	1.7	0.7	None
15	Ebute	74.6	3.0	19.0	2.0	1.0	0.3	None
16	Ekpe	98.9	2.0	28.5	2.7	1.7	0.7	Slight
17	Etem	92.5	3.0	16.0	2.3	1.3	0.7	None
18	Fakesta	98.4	3.0	23.3	2.7	1.3	0.7	None
19	Gandegbangi	98.2	2.3	19.0	2.7	1.7	1.0	Slight
20	Gbongi	98.6	2.7	22.0	3.0	2.3	1.0	Slight
21	Ibigbagede	77.1	3.0	6.6	1.7	1.3	1.0	None
22	Ifara	69.3	2.0	25.0	3.0	1.3	1.0	None
23	Igbom	91.5	2.7	23.0	2.0	1.3	1.0	Slight
24	Igbudugadu	76.2	2.7	30.0	3.0	1.3	1.0	None
25	Igyeiye	92.9	3.0	23.3	2.0	1.7	0.7	None
26	Iiyo	80.8	2.7	21.0	2.0	1.0	0.7	None
27	Ikohaakere	76.3	2.3	27.0	2.3	1.3	0.3	None
28	Ikookutom	85.5	2.7	30.2	2.0	1.0	0.7	Slight
29	Ikotama	68.9	1.3	24.0	1.3	0.7	0.3	Slight
30	Iphara	93.2	2.7	15.5	1.0	1.3	0.3	Slight
31	Isham	76.3	2.7	20.0	3.3	2.0	0.3	Slight
32	Jibo black	83.2	2.7	20.0	2.3	1.0	0.3	None
33	jibo white	68.5	2.7	14.0	3.3	1.3	0.3	None
34	Meccakusa	98.6	2.7	40.5	2.0	2.0	0.3	Slight
35	Myiomiyo	87.4	2.0	24.0	1.7	1.3	0.3	Slight
36	Nasarwa	74.2	3.0	32.0	2.7	1.3	0.3	Slight
37	Obiaoturugo	94.8	2.0	14.0	1.7	1.0	0.7	None
38	Ododio	68.5	3.0	16.4	1.7	1.7	1.0	None
39	Ogbuagu	90.5	2.7	30.0	3.3	1.0	0.3	None
40	Ogbudu	76.4	3.0	20.5	3.0	1.7	0.7	Slight
41	Ogine	87.3	3.0	26.0	2.7	1.3	0.3	None
42	Ogoja	82.4	3.0	25.9	2.3	1.7	1.0	Slight
43	Ogoma	83.6	2.7	17.0	1.3	1.3	1.0	None
44	Ojuiyawo	87.2	1.7	26.0	1.7	0.7	0.3	Slight

45	Okotebogba	100	3.0	32.6	1.7	1.7	0.7	None
46	Oku	81.5	2.3	13.0	1.7	1.0	0.3	Slight
47	Oyoyo	89.7	2.3	25.0	2.0	1.7	1.0	None
48	Ozhibo	89.2	3.0	21.3	2.7	1.3	1.3	Slight
49	Pouna	88.9	2.7	19.0	2.3	1.3	0.3	None
50	Punch	75.5	3.0	30.6	2.5	1.5	0.0	Slight
51	Sandpaper	94.8	2.3	31.0	2.3	1.3	1.0	None
52	Tarzoho	86.3	2.3	13.5	1.3	1.3	0.7	None
53	Utsuakpe	71.2	2.0	21.0	2.0	1.3	1.7	None
54	Yandu	67.8	2.7	23.0	1.7	1.0	0.3	Slight
55	Yotoyo	88.3	3.0	29.6	1.3	0.7	1.0	None
56	Okpambe	85.5	2.3	13.0	2.3	1.3	0.7	Slight
57	Damyou	85.2	2.7	21.0	2.0	0.7	0.3	Slight
	$LSD_{(0.05)}$	11.41	0.42	6.04	0.12	0.1	0.08	-

In vitro Assessment of some Botanicals as Potential Nematicide for Managing Parasitic Nematodes

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ABSTRACT

Laboratory experiment was conducted twice to compare the effects of aqueous extracts of some botanicals; leaves of brimstone (*Monrinda lucila*), bitter leaf (*Vernonia amygdalina*), Neem fruit (*Azadirachite indica*) and peel of sweet orange (*Citrus sinensis*) with that of Carbofuran (a synthetic nematicide) on the root-knot nematode *Meloidogyne incognita*). The experimental design was a 5x5 factoria experiment comprising of 5 treatments (plant materials and carbofuran) and five levels of application (0, 25, 50,75 and 100%) concentration of aqueous extracts of plant treatment and Carbofuran at (0, 2500, 5000, 7500 and 10000ppm) respectively. The various concentrations of aqueous extracts were tested on nematode egg hatch and juvenile mortality of *M. incognita*. The bioactive chemical component of the test plant materials were also determined appropriately. The mean value obtained from the two trials was determined and analyzed. The result from the experiment showed that the plant extracts and Carbonfuran caused significant reduction ($P \leq 0.05$) in nematode egg hatch as compared with control on day seven of the experiment. Egg hatch was 91% in control compared to 3.5%, 5.0%, 9.0% and 5.5% in 25% brimstone, bitter leaf, neem and citrus, while no egg hatch was recorded in 50, 75 and 100% in all test plant extracts and Carbofuran. The level of egg-hatch inhibition increased with increase in concentration of plant extracts and Carbofuran. Juvenile mortality was significantly higher

($P \leq 0.05$) in test plants and Carbofuran than in control. Within two days of the experiment, 100% mortality was observed in 1000ppm concentration of Carbofuran and all test plant extracts as compared to 0% mortality in the control. This observation showed that the test plants extracts are toxic to *M. incognita* and can be developed as raw materials for Bio-pesticide production and as replacement for h synthetic nematicides. Phytochemical analysis of the botanicals revealed the presence of flavonoid, taninin, alkaloids and flavonoids in the test plant extracts and are known to be toxic to parasitic nematodes.

INTRODUCTION

Plant parasitic nematodes are recognized as one of the major pests of tomato throughout the world, particularly on field crops in the sub-tropical regions. Many different species are known to cause damage but the most destructive nematode responsible for enormous yield loss of tomato are the root-knot nematodes belonging to genus *Meloidogyne*. The most wide spread and devastating root-knot nematode species on tomato are *Meloidogyne incognita*, *M. javria*, *M. arenaria*. Other species are *M. hapla, M. thamesi. M. gramicola* are known to infect crop in different parts of the world (Anonymous, 1983). The root-knot nematode *M. incognita* has been identified as a major constraint in production of most crop especially tomato (Ogunfowora, 1977, Abolusoro, 2014 Abolusoro 2019 ,Abolusoro,2020). The disease caused by this group of nematodes is root-knot disease characterized by numerous pronounced swellings, or galls on the roots of susceptible hosts plant. It is widely distributed and has extensive host range and interacts with other organisms such as fungi, bacteria and viruses in disease complex. The overall effect is to drastically reduce the quality and quantity of yield. In Nigeria, it has been estimated that over 140 plants are host to the root-knot nematode (Caveness, 1978; Oyedunmade *et al.*, 2000).

Scarcity, high cost, environmental safety and global restriction on the importation of chemical nematicides have spurred scientists to search for alternative control measures against nematode pests of economic crops (Anonymous, 2004). The use of palnt extracts for the control of nematodes pests had been suggested (Hoan and Davide, 1979). Application of plant extracts into the soil has the potential advantage of being economical, rapidly available and environmentally safe (Abolusoro, 2020 ,Olabiyi, 2004; Maqbool *et al.*, 1987).

The study was designed to evaluate the nematicidal action of some botanicals (*Morinda lucida, Vernonia amygdalina, Azadirachta indica, Citrus sinensis peel* and a synthetic nematicide (carbofuran) on the egg-hatch and juvenile mortality of *M. incognita* and to evaluate the various bio-active chemical components present in each of the test plants.

MATERIALS AND METHODS

Preparation of aqueous extracts of the test materials and the rates applied

The leaves of bitter leaf and brimstone, peel of sweet orange as well as fruit of neem were separately collected, air-dried and crushed into small pieces. One kilogramme of each plant was weighed on beam balance and soaked in one litre distilled water for a day. The content was filtered. The resultant filtrate was taken as the stock solution of the strength 100% (1,000,000ppm). Several dilution were made from the stock solution by adding appropriate amount of distilled water to obtain a solution of 25, 50, 75% in concentration as shown below:
1ml concentration plant extract + 3ml distilled water = 25%
2ml concentration plant extract + 2ml distilled water = 50%
3ml concentration plant extract + 1ml distilled water = 75%
Stock solution of 1,000,000ppmwas also made from carbofuran and water and then distilled in the manner similar to plant extracts to the following: 250, 500, 750 and 1000ppm respectively.

Extraction of M. incognita Eggs

Galled root collected from *Celosia argentea* on which a pure culture of *M. incognita* was properly washed under running water tap so as to get rid of the attached soil. The roots were cut into smaller pieces and shaken with 0.5% sodium hypochlorite solution in 500ml capacity conical flask (Hussey and Barker, 1973). The content was then sieved through a 200 mesh sieve nested on 500 mesh sieve. The upper 200 mesh sieve collected plant debris and small stones. The 500 mesh sieve now containing the eggs was placed under a running water on the laboratory so as to wash off any residual sodium hypochlorite solution. Rinsing was done for 20 minutes. Egg suspension was made inside a beaker of 500ml capacity. The number of eggs in 1ml suspension contained approximately 100 freshly hatched *M. incognita* egg.

Source of Root-knot Nematode Juveniles

Freshly extracted eggs were incubated at 28±2°C for 72 hours in the incubator to hatch out the second stage juveniles from them. Standardization of number of juveniles per unit volume was done so that 1ml juvenile suspension contained approximately 100 juveniles.

Laboratory experiment I: Effects of Carbofuran and plant extracts on M. incognita egg-hatch

Aliquots of 1ml *M. incognita* egg suspension containing a count of approximately 100 freshly extracted eggs of a *M. incognita* were dispersed into each of 105 transparent glass petrish-dishes containing 10ml of test plant extracts or carbofuran or distilled water only (control) as the case maybe. The concentrations of the aqueous extracts of test plants were 0, 25, 75 and 100% while the concentrations of carbofuran solution were 0, 250, 500, 750 and 1000ppm. The control represented 0% (0ppm). Treatments including control were repeated five times each and incubated at a room temperature of 28±2°C inside the incubator. The dishes were covered to prevent evaporation. The experimental design was a 5x5 factorial experiment. A count of un-hatched eggs and juveniles were made at 24hours interval for seven consecutive days under stereo microscope.

Effects of carbofuran and test plant extracts on the mortality of M. incognita Juveniles

Ten (10)ml of carbofuran solution at 0, 250, 500, 750 and 1000ppm concentration and 0, 25, 50 75 and 100% aqueous extracts were introduced into separate petri-dishes. Distilled water served as control (0%) standardized 1ml juvenile suspension containing 100 juvenile of *M. incognita* was introduced into each of the transparent petri-dish containing different treatments at various concentrations and were incubated at temperature of 28±2°C.

The petri-dishes were covered with glass to prevent evaporation. The experimental design was 5x5 factorial experiments. Each treatment was replicated five times. Counts of dead juveniles were made initially after 6 hours; 12 hours and 24 hours interval respectively for a period of 6 consecutive days. The juvenile that did not respond to touch of needle were recorded dead.

Phytochemical Screening

<u>Test for Alkaloids</u>

Principle: Alkaoids form an orange precipitate when mixed with Dregendorff's reagent (Harbone, 1976 and Cuile, 1969).

Procedure: 0.5g of each of the powdered plant materials were dissolved in 2ml methanol in a test tube, shaken vigorously and then heated for 2 minutes in a water bath. 2 ml of Dragendorff reagent was added. The bright blue colorizations in UV light and change of colour to orange red when sprayed with Dragendoff's reagent indicates the presence of alkaloids in the plant extract.

<u>Test for Flavonoids</u>

Principles: the formation of yellow colouration with sodium hydroxide solution was taken as an indication for the presence of flavoids in plant materials according to Trease and Evans (1989).

Procedures: 0.5g of each of the four powdered plant material was dissolved in 2ml method and heated in water bath for 2 minutes.

The supernatant was then decanted into another test-tube, into which 2ml of sodium hydroxide solution was added. The mixture was then observed for colour change. A reverse in colour change to colourless on addition of hydrocholric acid indicates the presence of flavonoids.

<u>Test of Saponins</u>

Principle: Saponin growth when shaken vigorously and precipitate in the presence of Feliling's A+B solution (Trease and Evans, 1978; Sofowora, 1982)

Procedure: 5g each of the powdered plant materials were dissolved in 50ml distilled water in 250ml beaker and allowed to soak for 3 hours. This was then filtered in Whatman No. 1 filter papers. The filterate was poured into a test tube, shaken vigorously and then heated in a water bath for 2 minutes. The persistence of growths indicates the presence of saponins.

<u>Test for Tannins</u>

Principles: Tannin forms a blue black, green or blue green precipitate with ferric chloride reagent (Tease and Evans, 1989.

Procedure: About 5g of each of the powdered plant materials were stirred with 10ml distilled water in a 250ml beaker and filter with Whatman's No. 1 filter paper. Ferric chloride was then added into the filterate in the same test tube. The formation of a blue black or blue green precipitate was taken as evidence for the presence of tannins.

RESULTS

Effects of Carbofuran and test materials on the egg hatch inhibition of *M. incognita* egg

The experimental results on the effects of Carbofuran, test plant materials and level of application on the egg-hatch of *Meloidogyne incognita* is presented in table 1.

Table showed that the test plant extracts were as effective as carbofuran in inhibiting the nematode egg hatch while all concentrations of the materials used for the treatment were significantly more effective than the control in inhibiting egg hatch. The lowest concentrations of the treatments were not as effective as higher concentrations. The table further showed that egg hatch was significantly lower in all the treatment throughout the experimental period than in the control.

Table 1: Effects of carbofuran and test materials and levels of application on percentage egg hatch of *Meloidogyne incognita*

MATERIALS	**DAY 1**	**DAY 2**	**DAY 3**	**DAY 4**	**DAY 5**	**DAY 6**	**DAY 7**
Carbofuran	3.55	6.90	7.90	12.80	15.70	16.70	18.60a
Morinda lucida	3.55	6.80	8.20	13.10	16.00	16.00	18.90a
Vernonia amygdalina	3.55	6.80	3.30	12.20	17.30	16.30	19.20a
Azadirachta indica	3.75	7.10	8.70	13.50	16.40	16.40	19.30ab
Citrus sinensis	3.46	7.50	9.00	14.20	18.70	17.10	20.00b
S.E.	0.461 NS	0.946 NS	0.739 NS	0.550 NS	0.630 NS	0.224 NS	0.224
LEVELS	**DAY 1**	**DAY 2**	**DAY 3**	**DAY 4**	**DAY 5**	**DAY 6**	**DAY 7**
0 (Control)	17.75b	33.00b	38.00c	62.00c	76.50	91.00c	91.00c
25%/250ppm	0.50a	2.10a	4.10b	4.80b	5.00b	5.00b	5.00b
50%/500PPM	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
75%/750PPM	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
100%/1000PPM	0.00a	0.00a	0.00a	0.00a	0.00a	0.00	0.00a
S.E.	0.461	0.946	0.739	0.55	0.636	0.224	0.244

Means followed by the same letter(s) along the same column are not significantly different at $P < 0.05$

.% level=test plant materials ,

,ppm level = carbofuran

Table 2 is the analysis of variance on the effects of Carbofuran and test plant extracts on the mortality of *Meloidogyne incognita.*

Table 2 showed that the test were as effective as Carbofuran in causing juvenile death while all the concentrations of the applied treatment materials caused significantly higher nematode death than the control. A hundred percent mortality was recorded at day 2 in all the treatments. The control experiment has the lowest percentage mortality during the experimental period. The level of juvenile mortality increased with increase in the exposure period. At the end of the experiment, an average of 100% juvenile mortality was observed in the test plants compared with the mean of 8.15% mortality in the control experiment.

Table 2: Effects of test materials and levels of application on percentage juvenile mortality of *M. incognita*

MATERIALS	**6Hours**	**12Hours**	**DAY 1**	**DAY 2**	**DAY 3**	**DAY 4**	**DAY 5**	**DAY 6**	**DAY 7**
Carbofuran	1630d	35.10d	80.00b	80.00b	80.00b	80.67	81.2	81.6	81.63
Morinda lucida	12.30c	28.10c	79.30b	80	80	80.67	82.69	81.69	81.7
Vernocia amygdalina	27.70c	79.20b	80.00b	80	80.69	81.2	81.39	81.7	81.7
Azadirachta indica	79.90b	23.10b	72.70a	80	80	80.67	81.2	81.69	81.7
Citrus sinensis	6.20a	18.80a	71.60a	79.2	79.2	80.67	81.2	81.61	81.63
S.E.	0.338	0.734	0.562	0.089 NS	0.000 NS	0.064 NS	0.064 NS	0.137 NS	0.119 NS
LEVELS	**6Hours**	**12Hours**	**DAY 1**	**DAY 2**	**DAY 3**	**DAY 4**	**DAY 5**	**DAY 6**	**DAY 7**
0 (Control)	0.00c	0.00c	0.00d	0.00c	0.00c	3.35b	6.00b	8.05b	8.15b
25%/250ppm	3.60d	17.9d	86.9c	99.2b	100.00a	100.00a	100.00a	100.00a	100.00a
50%/500PPM	8.10c	25.7c	95.9b	100.00a	100.00a	100.00a	100.00a	100.00a	100.00a
75$/750PPM	17.3b	39.3b	100.0a	100.0a	100.00a	100.00a	100.00a	100.00a	100.00c
100%/1000PPM	25.1a	49.9a	100	100.00a	100.00a	100.00a	100.00a	100.00c	100.00c
S.E.	0.338	0.734	0.562	0.89	0	0.64	0.224	0.137	0.119

Means followed by the same letter(s) along the same column are not significantly different at P< 0.05%

% level=test plant materials ,

ppm level = Carbofuran

Table 3 showed the active organic chemical ingredient in *A.indica* (fruit), *C. sinensis* (peel), *M. lucida* and *V. amygydalina* (leaf). The table showed the detectability or otherwise by chemical analysis of alkaloids, flavonoids, ,tannin and saponins contents in the various plant materials. The result showed that all the plant materials contained saponin, flavonoids and tannin to different content. However, alkaloids was detected only in *V. amygydalina.*

Table 3 showed the active organic chemical ingredient in *A.indica* (fruit), *C. sinensis* (peel), *M. lucida* and *V. amygydalina* (leaf).

Treatment	Saponin	Flavonoid	Tannin	Alkaloids
Azadirachta indica (neem fruits)	+	+	+	-
trus sinensis (sweet oranges peel)	+	+	+	-
Vernonia amygdalina (bitter leaf)	+	+	+	+
Morinda lucida (leaf of brimstone)	+	+	+	+

KEY

+ = chemical ingredient detected

\- = chemical ingredient not detected

DISCUSSION

The results from the experiment on the effects of plant extracts and carbofuran on egg-hatch inhibition and juvenile mortality showed that carbofuran and test plants were effective in inhibiting egg-hatch of *M. incognita* at the various concentrations they were tested. These observation showed that the fruit of *Azadirachta indica*, leaf of *Vernonia amygdalina*, the peel of sweet orange (*Citrus sinensis*) and leaf of *Morinda lucida* as well as Carbofuran were effective in causing egg-hatch inhibition in *M. incognita*. This inhibitory act increases with increase in concentration of the treatment applied. It was also observed that the longer the exposure time, the more the effectiveness of the treatments against the root-knot nematode egg-hatch and juvenile survival. The observed nematotoxic effects of the test plant extracts can be attributed to presence of nematicidal chemical components that were seriously injurious to *Meloidogyne incognita* egg and infective second stage juveniles. The use of plant extracts in control of phyto-nematodes have been reported by earlier researchers. Pandey (1990) reported the efficiency of aqueous extracts of the roots and shoots of the *Lactna sativa, Ammi majus Artemisia annua* which at concentration of 100% resulted in 100% *M. incognita* mortality within 24 hours of exposure in of exposure.Zavaleta-Mojia et al 1993, reported the the bio-nematicidal effects of Tagetes Species on root knot nematode pests.

Other researchers like Olabiyi 2005, Aboluroso *et al.*,2004, Adegbite and Adesiyan 2005, Abolusoro et al, 2018 reported effectiveness of different plant extracts in suppressing egg hatch and juvenile death of *Meloidogyne incognita* and other nematode genera. The result of this study showed that bio-nematicidal components are present in the leaf extracts of the utilized botanicals *(Vernonoia amigdalina, Morinda lucida, Azadirachta indica*) and this is responsible for their nematicidal properties against root-knot nematode *M. incognita.* This agrees with earlier researchers (Zuren et al 1984., Pandy, R 1990 Oyedunmade ,2000) who reported similar observation in their various research. .The bioactive agent, flavonoid was found in all the test plant materials. This is probably the reason responsible for the efficiency of the plant materials in reducing soil nematode population. This observation agress with Olabiyi (2004) who reported effectiveness of flavonoid in reducing *M. incognita* population as well as enhancing egg hatch inhibition. Further result obtained on analysis of saponin content of the test plant showed that all the test plant extracts contained saponin. In summary, one can conclude that alkaloid, flavonoid, saponins and tannins are the major bioactive components of the test plant materials. This observation agreed with by the findings of Sofowora (1982), Olabiyi (2005) who reported that alkaloids, flavonoids, saponins and tannins are principally contained in most medicinal plants in our environment, and incidentally, all the plants utilized are medicinal plants.

CONCLUSION

Various plant materials utilized for this research work are biochemically active and hence biocidal against root-knot and other parasitic nematodes of crops. The potential of these plant materials as biocidal agents against parasitic nematode has been established from this research findings. They can therefore be used as botanical control agents for managing plant parasitic nematodes as suitable replacement for environmentally harmful and bio-toxic synthetics that are currently been used for managing parasitic nematodes and others related biotic-stressors, ravaging crops and thereby reducing yield in quality and quantity. Agro-chemical companies can leverage on these plants as raw material for manufacturing nematicides of plant origin as a way of reducing environmental hazards due to the use of harmful synthetic chemicals for managing plant parasitic nematodes as well as other biotic stressors that tend to bring about yield reduction.

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Environmental And Breeding Year Effects On Agronomic Traits And Combining Ability For Grain Yield Of Some Tropical Maize (Zea Mays) Population

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ABSTRACT
Ten open-pollinated maize varieties developed between 1979 and 2008 classified into two breeding eras (1979 – 1999, Era 1; 2000 – 2008, Era 2) were crossed in a partial diallel fashion to generate 45 F_1 hybrids and their parents were studied for combining ability in five locations. Parent AMATZBR-WC_2B (era 2) with higher GCA effects, and cross combinations DMR-LSR-W (Era 1) x BR9928DMRSR (Era 2) and BR9922DMRSR (Era 2) x TZBRELD-$4C_0W$ (Era 2) with higher SCA for grain yield under low-N environment were identified as promising candidates for the development of nitrogen use efficient varieties for low-N environments. This study revealed the superiority of the cross combinations within the mordern maize varieties to the older ones. Parents TZBRELD-$4C_0W$ (Era 2) on the other hand, was the best general combiner for grain yield, and so could be used in the extraction of productive inbred lines for use in hybrid breeding programmes with a view to increase the yield level. It also an indication that the modern maize varieties combined well with other lines for maize grain yield. The study also revealed no environmental influence on combining ability for grain yield.

Keywords: combining ability, maize, eras, environmental, grain yield

INTRODUCTION
Development of population with high combining ability is a prerequisite to the efficient use of heterosis. In other words, the value of any population depends on its genetic potential *per se* as well as its combining ability when used in crosses. Consequently, analysis of combining ability allows the choice of parental populations to be used in breeding programmes. The use of genotypes with high combining ability is premised upon the belief that their progenies will give superior hybrids and segregating populations with large genetic variability. Combining ability can be classified as either general combining ability (GCA) or specific combining ability (SCA). The

concept of GCA and SCA was introduced by (Spague and Tatum, 1942) to distinguish between the average performance of parents in crosses (GCA) and the deviation of individual crosses from the average of the crosses (SCA). Lines that combine well with most others are said to have good GCA while those that combine well with only few other lines exhibit SCA. The Diallel mating design proposed has been used to determine the best parental combinations for hybridization either to exploit GCA effects and/or identify the best specific combinations (SCA) for both production and breeding purposes. Combining ability is not only good for improving population *per se* or predicting the best combiners, but it is also good for extraction of superior inbred lines for hybrid production. The heterosis and combining ability of tropically adapted early and intermediate matured maize germplasm of International Wheat and Maize Improvement Center (CIMMYT) was studied by using five CIMMYT gene pools and five maize populations to form the diallel crosses (Beck et al, 1990). The parents and their crosses were evaluated at five locations in Mexico, and one each in Colombia, Ecuador, India, and Thailand. Data were collected on plant and ear height, 50% days to silking and grain yield. The authors reported significant GCA effects for grain yield, plant and ear heights and days to silk and SCA effect only for ear height. Comparison of GCA with SCA sums of squares revealed predominance of additive genetic effects for both plant and ear heights. On the basis of good performance of intra-population hybrids observed in the study, the authors suggested that consideration should be given to the development of hybrids from lines from the same pool or population. In another experiment conducted by (Han, Vasal, Beck, et al., 1991) to examine the combining ability effects of inbred lines derived from maize population at CIMMYT. Fifty S_3 lines selected from different populations based on *per se* performance were divided into six sets to make six diallel crosses. Each diallel included 8 to 11 lines derived from 2 or 3 populations and crosses in each diallel set were evaluated in 3 to 4 locations during the 1986 and 1987 growing seasons. The results from the study showed that inter-population crosses were superior by between 4 and 16 percentage (%) over the intra-population crosses for grain yield. The authors also observed that while means of all inter-population crosses had positive SCA estimates, the intra-population line crosses gave negative SCA estimates for grain yield. The authors therefore concluded that on the average, inter-population crosses expressed greater heterosis for grain yield than intra-population crosses. Based on the observed differences in genetic diversity among population and pools, the authors hypothesized that as long as there is large genetic diversity within a population, crossing of lines from the same population or pools could also produce hybrids with good performance. Consequently, inter-population will therefore have little advantage over intra-population line crosses of the good population.

Combining ability and heterosis for grain yield and yield components in maize by crossing seven white was estimated using medium maturing inbred (S_6) lines from the IITA in all possible combinations to generate 21 F_1s (Ojo, Adedzwa, Bello., 2007). The 21 F_1s and their 6 inbred lines were evaluated during the early and late planting seasons of 1998 at the University of Agriculture, Makurdi, Nigeria. Data collected on ear length, ear diameter, shelling percentage and grain yield were used to estimate combining ability and high parent heterosis. Results of the study showed highly significant differences among hybrids for all the traits considered except ear length. As expected, hybrid means were significantly higher than the parental means for all traits except shelling percentage. Crosses involving Tropical x (Tropical x Temperate) lines produced hybrids with the highest heterosis for all traits. The highest inbred grain yield (4.79 t/ha) was obtained from Tropical x (Tropical x Temperate) hybrids while GCA and SCA means squares were not significant for ear length, ear diameter and shelling percentage. GCA mean squares were however highly significant and higher than SCA mean square for grain yield, indicating a predominance of additive gene action for grain yield. In another study (Yusuf and Ado, 2009), estimated the combining ability of quality protein maize (QPM) inbred lines evaluated at Samaru-Northern Guinea Savanna Zone of Nigeria. The 30 hybrids comprising fifteen single cross and fifteen reciprocal hybrids which were generated from the six QPM varieties along with the six inbred parents and 13 checks were evaluated for two years in a 7 x 7 partial lattice design. Their results showed highly significant GCA mean squares for all traits except for days to germination, emergence count and ASI. GCA effects were generally higher than SCA effects indicating predominance of additive over non-additive gene action. However, SCA effects were significant for % protein, moisture content, ear height and one thousand grain weight. Apart from highly significant negative SCA effects for days to maturity for some crosses which identified them as good candidates for developing early maturing hybrids, the authors also reported high but significant negative SCA effects for plant and ear heights which is an indication of short stature which is desired for mechanical harvesting.

The line × tester mating design involving five maize lines and four testers was used to estimate GCA and SCA effects and also determine high parent heterosis for maize traits under moisture deficit conditions in Northern Guinea and Sudan savannas of Nigeria (Aminu and Izge, 2013). Results in respect of combining ability analysis revealed that both additive and non-additive gene actions were important in days for 50% tasselling and silking, ASI, plant height and ear placement. However, there was a preponderance of non-additive gene action for almost all the traits investigated, with parents Ex-Damboa White, EVDT-99WSTRQPMCO, EVDT-99WSTRCO and TZE-COMP3DTC1 being the best general combiners among the parents. Cross combination EVDT-99WSTRQPMCO × Ex-Biu White was identified as the best specific combiner among the 20 hybrids evaluated in days to tasseling and silking. The hybrid also recorded high parent heterosis for grain yield. The authors therefore recommended the use of the hybrid in an area with marginal rainfall as a means for exploiting heterosis for grain yield and earliness. However, there is likelihood that continuous change in breeding objectives may alter positively or negatively the combining ability for some target traits. The objective of this study therefore was to compare the combining ability of ten tropical maize varieties developed between 1979 and 2008 classified into two breeding eras (1979 – 1999 Era 1/ older varieties; 2000 – 2008, Era 2/newer varieties). The study was also aimed at identifying the superiority of combining ability of crosses within newer and older, or between newer and older varieties respectively.

MATERIALS AND METHODS

The materials studied were ten tropical maize varieties developed between 1979 and 2008 classified into two breeding eras (1979 – 1999, Era 1/older varieties; 2000 – 2008, Era 2/newer varieties) The ten open-pollinated varieties were crossed in a partial diallel fashion to generate 45 F_1 hybrids at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The 45 F_1 hybrids were tested under six environments viz: Ikenne (Latitude 6^0 53^1N, Longitude 3^0 42^1E) and Ile-Ife (Latitude 7^0 18^1N, Longitude 4^0 33^1E) (rain forest region) were regarded as optimal/stress free environments. Mokwa (Latitude 9^0 18^1N, Longitude 5^0N 4^1E) and Zaria(Latitude$12^0 00^1$N, Longitude 8^0 22^1E) (Guinea savanna) which were the last four for Nitrogen (N) study where the genetic materials were evaluated under high and low N conditions (30kg/ha and 90kg/ha) respectively. In all evaluations, two row plots were used. Each row was 6m in length, spaced at 0.75m between rows 0.25m within rows with four replications to give a population density of approximately 53,333 plants per hectare height.

ANALYSIS OF COMBINING ABILITY

Both general combining ability (GCA) and specific combining ability (SCA) were computed using method 4 model 1 (parents and crosses together without reciprocal) (Griffing., 1956)

3.5.1.2 GENERAL COMBINING ABILITY (GCA) effect was computed as

$g_i = 1/2n(Y_i. + Y._j) - 1/n^2 Y.,$

Where: g_i = general combining effect of i^{th} line

n =number of lines involved in the cross

$(Y_i + Y_j)$ =sum of cross products from diallel table

Y., = total sum of products from diallel table

RESULTS

Environmmental effects were not significant for maize grain under optimal condition in Ife and Ikenne, however, they were highly significant under low and high regime (Table 1). Variation among the genotypes for grain yield were not significant under optimal environment, but were highly significant under low and high N environments. Both GCA and SCA varied significantly for grain yield under low, while only SCA was significantly different under high N condition. G x E, GCA x Env and SCA x Env were not significantly different under across the six tested environments. The values of SCA/GCA were less than 1 i.e. GCA/SCA is greater than 1.

COMBINING ABILITY UNDER OPTIMAL ENVIRONMENT

The estimates for GCA effects in respect of grain yield and related traits across natural field conditions in 2012 (i.e. Ikenne and Ife) are presented in Table 2. GCA effects for grain yield was significant and positive for DMR-LSR-W, while it was negative but non-significant for other parents. Parent DMR-LSR-W obtained the highest values of the estimate of GCA effects for grain yield under natural field condition at Ikenne and Ife. However, all other parents had low and negative GCA effect across the environments. Maize grain yield assessment under natural field condition showed that DMR-LSR-W combined generally well with TZSR-W-1, TZSR-Y-1, TZSR-W-1, ACR99TZLCOMP-4DMRSR, BR9922DMRSR, BR9928DMRSR, BR9943DMRSR, AMATZBR-WC$_2$B and TZBRELD.4C$_0$W. All other cross combinations had low and non-significant GCA effects for grain yield under natural field environment

Across high-N environments, the estimates of GCA effects for grain yield were high and positive in parents BR9922DMRSR, BR9943DMRSR and TZBRELD.4C_0W (Table 4). Significant GCA effect was also recorded for number of ears per plant in DMR-LSR-Y under the same condition.

DISCUSSION

Formulation of comprehensive breeding strategies for yield improvement depends mostly on the understanding of the nature of gene action involved in the expression of specific traits. Thus, combining ability is one of the powerful tools in identifying the best cross combinations that may be used either to exploit heterosis or accumulate productive alleles for the desired traits. As a tool, it also facilitates the understanding of the genetic basis of expression of many characters that enable the plant breeder design effective breeding method for future improvement programmes. Furthermore, dominance (non-additive gene action) is desirable for developing superior hybrids while additive gene action implies that standard selection protocols would be effective in breeding strategy aimed at improving the character (Edwaqrds et al, 1976). The significant GCA and SCA mean squares recorded for grain in both stress and stress-free environments revealed that both additive and non-additive gene actions were important in the inheritance of the traits under the specific environments in which the studies were conducted. It also confirmed that there is wide genetic variability inherent in the populations that could be exploited for genetic improvement of grain yield. The results, therefore, suggest that additive type of gene action is primarily involved in determining grain yield across the different environments Tested. These results agree with the report of who found the preponderance of additive genetic effects in the control of most traits in maize. In earlier studies (Beck, Vaal, Carossa., 1990; Gama, Hallauer, Ferrao et al., 1995) reported the predominance of additive over non-additive gene effect for maize grain yield while (Bello and Olaoye, 2009) also reported the preponderance of GCA

effects in the expression of traits in maize genotypes under striga infested condition. Aly, Malik, Choudhry, et al., 1999) indicated that both GCA and SCA were significant for grain yield. This is similar to an earlier study conducted by (Amiruzzaman, Islam, Hassan, et al., 2010) on combining ability and heterosis for yield and component character in maize. The fact that both additive and non-additive gene action were important in genetic control of grain yield implies that there is existence of tremendous amount of variability in the genetic materials. The author observed that the significant positive SCA effects for ear length, kernels per ear and kernel weight were more frequently associated with significant estimate of SCA effects for grain yield. Parent AMATZBR-WC_2B with higher GCA effects and mean values for grain yield, and cross combinations DMR-LSR-W (Era 1) x BR9928DMRSR (Era 2) and BR9922DMRSR (Era 2) x TZBRELD-4C_0W (Era 2) with higher SCA for grain yield under low-N environment on the other hand, are promising candidates for the development of nitrogen use efficient varieties for cultivation in low-N environments. This study also revealed the superiority of the cross combinations within the more recent maize varieties to the older ones. Parents TZBRELD-4C_0W (Era 2) on the hand, was the best general combiner for grain yield, simultaneously possessed high mean values under high-N other environment, and so could be used in the extraction of productive inbred lines for use in hybrid breeding programmes with a view to increase the yield level. It also an indication that the modern maize varieties combined well with other lines for grain yield under adequate supply of nitrogen relative to older varieties.

CONCLUSION

Parent AMATZBR-WC$_2$B with higher GCA effects and mean values for grain yield, and cross combinations DMR-LSR-W (Era 1) x BR9928DMRSR (Era 2) and BR9922DMRSR (Era 2) x TZBRELD-4C$_0$W (Era 2) with higher SCA for grain yield under low-N environment, can be suggested for the development of low N nitrogen tolerant hybrid maize for cultivation in low-N soil condition. This study also revealed the superiority of the cross combinations within the more recent maize varieties to the older ones. Parents TZBRELD-4C$_0$W (Era 2), was the best general combiner for grain yield, so could be used in the extraction of productive inbred lines for use in hybrid breeding programmes with a view to increase the yield level. The study also revealed that modern maize varieties are good general combiners for maize grain yield, they are therefore better sources of genes for maize grain yield development compare to older varieties

AUTHOR CONTRIBUTIONS

S.A.I., developed the concept and wrote the manuscript, S.A.A. did part of analysis, C.A. took the field parameters, D.A did the statistical analysis, O.B. designed the field experiment and reviewed the manuscript. . All authors have read and agreed to the publishedversion of the manuscript

COMPETING INTERESTS

The authors declare no competing interests.

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Table 1: Analysis of variance for combining ability across (Ikenne & Ife, Mokwa & Zaria (HN), Mokwa & Zaria (LN)

Source of variation	Ife & Ikenne Yield t/ha	Mokwa & Zaria Low-N Yield (t/ha)	Mokwa & Zaria High-N Yield (t/ha)
Environment	2217.14	591.3**	593.11**
	2501.97		4.26**
Rep/Env		6.80**	
	2556.04		1.18**
Genotype		0.72**	
	4708.35		1.80
GCA		0.87**	
	2125.57	0.69**	1.26**
SCA			
	2553.3	0.42	
Genotype x Env			0.58
	4724.83	0.32	0.46
	2118.99	0.45	0.61
SCA x Env			
	2571.59	0.41	
Pooled error			0.52
SCA/GCA	0.45	0.79	
			0.7

*,** Significant at < 0.05 and 0.01 levels of probability respectively.

Table 2: General and Specific combining ability (GCA and SCA) for grain yield across natural field condition

(Ikenne and Ife, 2012)

	DMR-LSR-W	DMR-LSR-Y	TZSR-Y-1	ACR9922TZ LCOMP4-	BR9922 DMRSR	BR9922 DMRSR	BR9943 DMRSR	AMATZBR -WC2B	TZBRELD. 4C0-W	GCA
TZSR-W-1	-20.1	2.1	2.0	2.1	1.7	2.4	2.2	2.0	2.2	-2.3
DMR-LSR-W		20.1*	20.1*	20.2*	20.0*	19.9*	19.9*	20.3*	19.9*	19.9*
DMR-LSR-Y			2.3	2.2	1.7	2.3	2.3	2.0	2.0	-2.4
TZSR-Y-1				2.2	2.0	2.0	2.1	2.0	2.2	-2.3
ACR99TZLCOMP4-DMRSR					1.8	2.2	2.0	1.8	2.1	-2.1
BR9922DMRSR						2.0	2.1	2.7	2.0	-2.1
BR9928DMRSR							2.4	1.9	1.8	-2.2
BR9943DMRSR								2.1	1.9	-2.1
AMATZBR-WC2B									1.9	-2.2
TZBRELD.4C0W										-2.2

*,** Significant at < 0.05 and 0.01 levels of probability respectivel

Table 3: General and Specific combining ability (GCA and SCA) for grain yield across Low-N environment (Mokwa and Zaria, 2012)

Genotype	DMR-LSR-W	DMR-LSR-Y	TZSR-Y-1	ACR9922TZ LCOMP4-DMRSR	BR9922 DMRSR	BR9928 DMRSR	BR9943 DMRSR	AMATZBR DMRSR	TZBRELD.4C0-W.	GCA
TZSR-W-1	-0.15	0.03	-0.06	-0.01	-0.28	0.36	0.09	0.23	-0.04	-0.10

DMR-LSR-W	0.06	-0.13	-0.03	0.24	0.61	0.07	-0.15	-0.11	-0.08
DMR-LSR-Y		0.24	-0.01	0.17	0.04	-0.04	-0.25	0.12	-0.12
TZSR-Y-1			0.52	-0.19	-0.09	0.40	0.17	-0.09	0.08
ACR99TZLCOMP4-DMRSR				-0.03	0.28	-0.003	0.27	-0.12	0.04
BR9922DMRSR					0.05	-0.26	0.003	0.61	0.03
BR9928DMRSR						0.12	0.27	0.02	0.05
BR9943DMRSR							0.2	0.22	-0.12
AMATZBR-WC2B								0.15	0.16
TZBRELD.4C0W									0.05

*,** Significant at < 0.05 and 0.01 levels of probability respectively.

Table 4: General and Specific combining ability (GCA) and(SCA) for grain yield under High-N environment at Mokwa and Zaria, 2012

Genotype	DMR-LSR-W	DMR-LSR-Y	TZSR-Y-1	ACR9922TZLCOMP4-DMRSR	BR9922DMRSR	BR9928DMRSR	BR9943DMRSR	AMATZBR-WC2B	TZBRELD.4C0-W	GCA
TZSR-W-1	0.02	0.02	-0.33*	-0.71**	0.54**	0.38*	0.31*	0.21	0.002	-0.15

DMR-LSR-W	0.27*	0.16	0.29*	-0.21	-0.12	0.06	0.21	0.25*	-0.03
DMR-LSR-Y		0.17	0.04	0.04	0.13	0.06	-0.04	-0.24*	-0.15
TZSR-Y-1			-0.06	-0.06	0.27*	0.21	0.11	-0.10	-0.03
ACR9922TZL COMP4-DMRSR				0.06	0.15	0.09	0.23	-0.23	0.04
BR9922DMRSR					-0.1	-0.16	-0.52**	0.27*	0.10
BR9928DMRSR						-0.33	0.31	-0.144	-0.03
BR9943DMRSR							0.25	0.29*	0.08
AMATZBR-WC2B								-0.06	0.05
TZBRELD.4C0W									0.11

*,** Significant at < 0.05 and 0.01 levels of probability respectively.

Postharvest losses under forest seed management and its effect on seed quality and yield

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ABSTRACT
Quality seed is a prerequisite to uniform stand establishment which fabricates a pathway towards high yielding forest seed products. Seeds are produced and dispersed in such a way as to optimize their survival from predators and in competition with other species. However apart from the dispersal mode, seed collection and handling play major role in the yield and quality of forest tree species meant for conservation and afforestation programs. Seeds of many tree species are easy to handle and store for long periods of time, whilst others are very difficult and need special treatment to maintain viability. This paper highlights the importance of postharvest techniques that should be put into consideration to avoid huge losses that could result to reduction in productivity and availability of species' seeds.
Keywords: Quality seed, Harvesting, Processing, Storage,

INTRODUCTION
Seed in its entirety is basically the biological material exhibiting a wide range of biological variation in morphology and physiology. For sustainable production of agricultural and forestry growth and establishment, production of quality seed remains high priority. Quality seed is a prerequisite to uniform stand establishment which fabricates a pathway towards high yielding forest seed products. Seeds are produced and dispersed in such a way as to optimize their survival from predators and in competition with other species. However apart from the dispersal mode, seed collection and handling play major role in the yield and quality of forest tree species meant for conservation and afforestation programs (Lars, 2007). Seeds of many tree species are easy to handle and store for long periods of time, whilst others are very difficult and need special treatment to maintain viability (Neya, 2006). Some seeds are liable to damage by insect pests and diseases even when they are maturing on the trees or under storage rendering them completely nonviable. The productivity and quality of tree species are affected by some constraints experienced by

absence of planting materials, harvest and most especially postharvest management. The postharvest seed storage between growing seasons is a necessary step linking plant regenerations and sustainability. The main factors responsible for postharvest losses are lack of proper packaging, no precooling, no proper transportation, lack of good storage techniques amongst others. All these factors have contributed to a great loss of seed quality and quantity at postharvest stage. Aidoo (1993) revealed that about 20 % losses results from majorly Africa and other Asian countries. Kader (2005) reported that less than 5% of resource allocation from agricultural research in developing countries is on postharvest while the remaining 95% is mainly on the production. In order to avoid huge losses right from the harvesting stage to production, preventive measures and handling practice must be put in place to reduce postharvest losses. In this paper we will examine the ways by which post -harvest losses can be reduced to prevent the risk of seed loss before next crop seasons and also increase the shelf life of harvested fruits/seeds.

Postharvest Techniques for Forest Seed Management

Healthy seeds must be stored for maintenance of high yielding crops. According to Watkins and Nock (2012) the primary objective of postharvest handling is to maintain quality by reducing metabolic rates and water loss that result in undesirable changes in colour, composition, wilting, shriveling, spoilage caused by decay and preventing development of freezing injury or physiological disorders. Once appropriate postharvest handling techniques are put in place there is possibility of moderate reduction in the losses of seeds and also achieve high quality seeds of both national and international standards.

Seed Collection and Harvesting

Seed quality is the measure of the potential to produce desirable quality, healthy, and high yielding crops at low planting rates (Greggs and Billups, 2010). It is imperative to note that a good tree starts from a good seed, thus it is justified to pay attention to what is being collected regardless of the succeeding procedures of seed handling. Although the act of seed picking from the ground floor seems to be the easiest and preferred but poses to be at risk of contamination, however seed collectors have come to realize that good seed must be collected from the mother tree before it falls or is dispersed. This will ensure that healthy seeds are collected right before they are dispersed or attacked by predators, insects and other degrading factors. After harvesting and collection, subsequent handling procedures are necessary to ensure that all data are noted for record purposes. Collection containers mostly used for bulk storage must be tight and cleared of all seeds and debris from previous collection as this will reduce the risk of contamination. Seeds to be stored or preprocessed must be viable until the processing stage.

Seed Cleaning and Processing

The essence of seed cleaning is to make seed storable, the ease or difficulty of cleaning seed may influence the collection method, most especially ground collection. Although ground picking/collection maybe easy, the collected seeds tend to more infested by pathogens more than those pick from the trees. Seed processing refers to the handling procedures between collection and storage or sowing which aims at achieving clean, pure seeds of high physiological quality (germinability) which can be stored and easily handled during succeeding processes such as pretreatment, transport and sowing (Lars, 2007). This process categorized into pre cleaning, procuring, extraction, dewinging, cleaning, grading and adjustment of moisture content. Seed processing should be done to get high quality seeds at a sufficiently high rate per hour to minimize the cost and make it commercially viable. In processing, a risk of damage or injury usually occur to some seeds; mechanical damage, heat damage, chemical damage and water damage. The more fragile the seeds the more sensitive it is to damage hence adequate care and precaution must be ensured during cleaning and processing.

Seed Storage

Storage may be defined as the preservation of viable seeds from the time of collection until they are required for sowing. One of the first considerations when deciding how to collect and handle seeds of a particular species is storage behavior. Although once seeds meant for regeneration and afforestation can be sown immediately after collection, no storage is needed. Seed lots should be sown before the germination percentage drops below 80-60%. Generally, seed lots are discarded once the germination percentage falls below 50%. The seed survival duration is different for different species and also depends on the actual condition of the seeds as well as the external factors; among those, seed moisture, storage room temperature, and the presence of diseases and pests are considered most important. Probert *et al.* (2007) explained that if fruits/seeds have a very high relative humidity at harvest (85%–100%) and if resources are available to create a controlled, non-desiccating environment, they should not be rapidly dried. Seed quality is likely to increase if such seeds are held under conditions (temperature, humidity) that are close to the conditions that they would experience if they remained on the maternal plant. Further research reveals that metabolic activities, age and longevity of seeds can be manipulating by controlling the humidity, temperatures and oxygen (Mohammed, 2014). Reduction of seed moisture content up to an appropriate limit as the seed could be damaged because of desiccation and seeds could be stored for a longer period due to a lower level of humidity.

Table 1: List of Tree Species, their seeding period, viability and number of seeds per kg

Species	**Seeding period**	**Storage period/ Viability**	**Number of seeds per kg**
Terminlia ivorensis	December-January	12 months and above	4,500
Terminalia superba	July-October	6 months	4500-4700
Shorea roxhburgii	January-April	1-2 months	1500-1600
Gmelina arborea	December-March	9 months	1500-1600
Entandrophargma angolense	November- January	6months	2000
Acacia nilotica	May-June	1 year and above	6000-8500
Tectona grandis	November-February	12 and above	1400-1500
Periscopsis elata	December-April	12months	3,578
Nauclea diderrichii	September-January	12 months and above	40,000
Moringa oleifera	All year round		3500
Khaya senegalensis	December-March	6 months	4700
Mansonia altissima	December-March	12 – 16 months	2600-3000
Albizia lebbeck	November-April	12 – 36 months	1400
Azadirachta indica	July-september	6 months	2600-2800
Parkia biglobosa	December-March	18-24 months	2500-2700

Source: Seed Technology and Management Unit, FRIN

Storage losses

The main purpose of storage in any agricultural or forestry programme is to avoid biological and financial losses of the yield obtained after harvest, this help in reducing the crop losses. The damage that usually occur in different seeds is simply relative to their storage temperature, seed moisture content and rate of seed drying. Based on this vast information it is imperative that storage losses can be reduced to the barest minimum to avoid yield loss. Tree species are categorized into three storage behavior; recalcitrant, intermediate and orthodox. Different researches have been conducted to actualized and determine the storage behavior of some tree species and the results have shown a huge impact on how to differentiate the species (Hong and Ellis, 1996; Pritchard et al. 2004; Wood et al. 2000; Hay et al. 2000; Tuckett et al. 2010). This would also help in adjusting the appropriate measures on how to improve the storability of seeds. Desiccation-sensitive recalcitrant seeds are shed from the tree after maturation, with high moisture content, high metabolic activity and poor storage potential and this leads to significant challenge for ex situ conservation through seed-gene bank (Umarani *et al*, 2015). Berjak and Pammenter (2008) also gave practical advice for the conservation of recalcitrant seeds, seeds should be kept at their harvest (or shedding) moisture content and at the lowest temperature that does not incur chilling damage. Apart from the seed storage behavior other factors to consider during storage losses are the losses that directly affect the stored seeds. Pests namely rodents, insects, mites, birds, microorganisms such as mould and bacteria are among the biological factors that responsible for deterioration fruits/crops. The microbiological and biological effect on seeds can result from susceptibility to infection and damage by pathogens during storage.

Ways to prevent storage losses

Postharvest losses can be considered as one of major challenge undermining food security and income generation. The inability to maintain and sustain seeds of high quality can also be seen as a hindrance to its production and productivity in most developing countries. Good post-harvest handling is crucial in ensuring a quality product. When cultivation, harvest, and particularly postharvest operations are handled with utmost care, hence a good quality and a safe end-product are ensured. (Melanie & Michael, 2011). Seed quality needs to be maintained for the better quality fruits/crops. It is important to note that prompt harvesting at optimum stage, adequate transportation to processing units, handling and cleaning, well packaging methods and appropriate storage facilities are steps in reducing postharvest losses. Improved modern processing method is required to increase the shelf life and quality of seeds of tree species. Ability to access loan to buy improved postharvest facilities and equipment is also another fundamental way to enable smallholder farmers and small-to-medium enterprises to ensure reduction in losses. The storage capability of cold chain equipment and infrastructure can also help by substantially reduce losses of fresh produce directly from the farm. Access to good road network is another way to help minimize losses, improved road infrastructure from the forests/farms will lower transport time and also reduce the risk of damaging produce most perishables.

RECOMMENDATION AND CONCLUSION

Seeds are liable to damage by diseases even when they are maturing on the trees or under storage rendering them completely nonviable. To avoid damage and minimize postharvest losses, it is important to put in place necessary measures Appropriate prompt harvesting time and subsequent storage conditions should be maintained; Establishment of small and large processing facilities should be on readily available; During seed cleaning/ handling, infested seeds should be avoided and removed from the seed lot before storing, as this will reduce multiplication of infested seeds; Accessibility to right packaging; designing and manufacture of good quality and affordable packaging material for those that recalcitrant in nature and likely perishables; Avoid multiplication and further damage of storage seeds;The use of indiscriminate of non-recommended ripening chemicals should be avoided; Appropriate training manual and conduct of training by professionals and forest extension officers on various aspects of postharvest management can be considered a step in preventing wastage

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Comparative effects of different levels of indole-3- butyric acid (iba) and coconut water on the cuttings of *shorea roxyburghi* g.don.

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ABSTRACT

Despite its medicinal purpose, *Shorea roxburghii* G.Don is considered threatened in Nigeria due to its collection and its slow growth via seed propagation. This study was conducted to assess the effects of growth hormones on sprouting and rooting ability of *Shorea roxburghii*. Stem cuttings from mature plants were treated with two different types of growth regulators: Indole-3-Butyric Acid (IBA) and coconut water while untreated cuttings were used as the control. The experiment was laid in a completely randomized design with five treatments replicated four times. The following parameters were assessed: percentage survival, number of roots, sprout count and root length. The results assessed show that the growth regulators had no significant effect on the sprout count. Other parameters assessed i.e. percentage survival, number of roots and root length were significantly different to the effect of growth application. From the result, it is observed that T4 (coconut water extract) indicates the highest mean value of 96.47 among the treatments applied. It can concluded that coconut water extract can be extensively used to establish mass propagation of *S. roxburghii*.

Keywords: *Shorea roxburghii*, IBA, coconut water extract, stem cuttings

INTRODUCTION

Shorea roxburghii G. Don is a deciduous tree with simple alternate leaves and belongs to the family Dipterocapceace. The species is predominantly found in dry deciduous forest of India evergreen or semi evergreen dipterocarp forest of Malaysia, Thailand and Indochina (Bolanle-Ojo *et al*, 2014 and Ho Wai mun *et al*, 2018). It is suitable for general utility purpose, light to medium construction, and is very popular as a plywood. The propagation of plants by seeds is comparatively easy, fast and reliable.

Seed can be considered as the starting structure in the life of seed plants. Successful seed germination depends on numerous internal and external factors. However, vegetative propagation or clonal multiplication has become popular and also shown an advantage of developing true-to-type and disease free clones of great importance both economically and commercially (Kochhar *et al*, 2008). Asexual or vegetative propagation of plants is that form of plant propagation in which this new individual possesses exactly the same characteristics as the parent plant from which it was taken (Sandra and Mack, 2011; Gupta *et al*., 2002).

Reproduction of new plants is very possible through the formation of adventitious roots and shoots because every cell of the plant contains the genetic information necessary to regenerate the entire plant (Amir, 2010). In cases where seeds are recalcitrant such as *Shorea roxburghii* as it affects its viability, it is equally important to devise a way to increase its mass propagation for environmental purposes (Noraliza *et al,* 2017). The effect of germination stimulants such as Indole butyric acid (IBA), Napthelene acetic acid (NAA) and Gibberelic acid (GA) are most evident on root initiation and shoot initiation and production. Natural extracts such as honey, garlic extract, *Eucalyptyus* spp, moringa extract, and coconut water extract that act as growth regulators are also often used as they are easily available at low cost purposes. Among natural extracts that can be used for sprouting ability in plants is the coconut water extract. Coconut water extract has been proven to contain some class of bio compounds such as auxins, gibberellins, cytokinnins and other natural inhibitors (Yong *et al*, 2013; Ge *et al*, 2007 and Mamaril *et al*, 1988). This natural extract is considered as a cheap source of growth regulators which is easily assessable and environmentally friendly. Coconut water extract is well known as an organic supplement containing mineral nutrients and phytohormones such as cytokinnis, auxins, gibberellins and abscisic acid. Its influence on stem cuttings of forest tree species has proven to be effective and easy to use unlike synthetic growth regulators. Due to its organic components, noticeable changes are observed in its usage to stimulate cell growth, shoot formation and production, apical bud formation and rapid root formation (Razdan, 2003; Kieber, 2002; Caboni *et al*, 1997; Blazkova *et al*, 1997). This paper therefore aims to compare the influence of natural extracts (coconut water extract) and synthetic growth hormones at different levels on the vegetative propagation of *S. roxburghii* G. Don with a view of determining its sprouting ability so as to domesticate and conserve while propagating it with appropriate methods.

MATERIALS AND METHOD

One hundred single node leafy stem cuttings of *Shorea roxburghii* were obtained from 18 month old seedlings. The seedlings were decapitated and stem cuttings were obtained from the single node position of the seedlings. The cuttings were then treated with Indole butyric acid (IBA) at the following concentrations, 0, 50, 100 and 150 mgL^{-1} and coconut water. The cuttings were treated with the growth regulators using the quick dip method (Akinyele, 2010) and set in washed sterilized river sand in germination trays, watered twice daily with a hand sprayer and laid out in a completely randomised design under the high humidity propagator. Twenty cuttings were allotted to each treatment and replicated four times with treatments as follows T1 (IBA 50), T2 (IBA100), T3 (IBA150), T4 (Coconut water) and T5 (Control). Data was collected after 60 days for percentage survival, sprout count, number of roots and length of roots per cuttings. The length of roots was assessed with the use of metre rule while the other parameters were assessed using physical count. The data collected was then analysed using analysis of variance (ANOVA) and treatment means were compared using LSD test at probability level of 0.05%.

RESULTS AND DISCUSSION

The retention of leaves is important for cuttings as they do not possess large reserves and the persistence of physiologically active leaves and development of buds into branches are prominent signs of rooting of cuttings (Fadwa and Yahia, 2014; Akinyele, 2010). From the result below, T4 (coconut water extract) has shown the highest mean values from the parameters used in this study as compared to the application of synthetic growth regulators. T1 (IBA 50) shows the least value from the parameters observed.

Table 1: Effect of plant growth regulators on the stem cuttings of *Shorea roxburghii* G.Don

PLANT REGULATORS	NUMBER OF ROOTS	ROOT LENGTH	PERCENTAGE SURVIVAL	SPROUT COUNT
IBA 50	6.53	5.61	70.64	6
IBA 100	11	6.02	73.7	5.78
IBA 150	12.1	6	80.3	6.33
COCONUT	14.5	12.64	89.7	7.45
CONTROL	13.2	8.16	87.0	6.22

Table 2: Analysis of Variance (ANOVA) for Number of roots on stem cuttings of *S. roxburghii* G. Don within 8 weeks of study

SV	Df	SS	MS	F-cal	P-Value
Treatments	4	110.143	27.536	7.080	.006*
Errors	10	38.891	3.889		
Total	14	149.034			

*=significant at P<0.05

The result of ANOVA indicated that there was significant difference (p< 0.05) in the effect of plant growth regulators on *S. roxburghii stem* cuttings. Post hoc shows that T4 had the highest mean separation on the number of roots while T1 had the least value (Table 6).

Table 3: Analysis of Variance (ANOVA) for Root Length (cm) on stem cuttings of *S. roxburghii* G. Don within 8 weeks of study

SV	Df	SS	MS	F-cal	P-Value
Treatments	4	74.016	18.504	6.617	.007*
Errors	10	27.964	2.796		
Total	14	101.980			

*=significant at P<0.05

Table 3 shows that the effect of plant growth regulators on root length on the stem cuttings of *S. roxburghii* is significantly different and the mean separation indicates that T4 had the highest value (10.6800 ± 0.01^{b}).

Table 4: Analysis of Variance (ANOVA) for Percentage Survival on stem cuttings of *S. roxburghii* G. Don within 8 weeks of study

SV	Df	SS	MS	F-cal	P-Value
Treatments	4	3.151	3.151	3.861	.038*
Errors	10	2.040	2.040		
Total	14	5.191			

*=significant at P<0.05

There is significant difference (p<0.05) in the effect of plant growth regulators on the percentage survival on stem cuttings of *S. roxburghii* within the period of the study. The mean separation test shows that T5 had the highest value on the percentage survival while T2 had the least value.

Table 5: Analysis of Variance (ANOVA) for Sprout Count on stem cuttings of *S. roxburghii* G.Don within 8 weeks of study

SV	Df	SS	MS	F-cal	P-Value

Treatments	4	4.264	1.066	.714	.601^{ns}
Errors	10	14.930	1.493		
Total	14	19.194			

^{ns} = Non- significant at P>0.05

Table 5 shows that there is no significant difference on the sprout count on the *S. roxburghii* stem cuttings.

Table 6: Post- hoc Test for Number of roots, Sprout count, Root length and Percentage Survival of *S. roxburghii* G.Don cuttings within 8 weeks of study

Treatments	Number of roots	Root length	Percentage survival
T1(IBA 50)	6.5533±0.03 ^{a}	4.2633 ±0.13 ^{a}	88.800±0.01 ^{ab}
T2 (IBA100)	11.0000±0.14 ^{b}	6.0233±0.22 ^{a}	82.233±0.02 ^{a}
T3 (IBA 150)	12.1000±0.13 ^{b}	5.1000±0.03 ^{a}	88.900±0.10 ^{ab}
T4 (C/WATER)	14.4467±0.14 ^{b}	10.6800±0.01^{b}	93.367±0.03 ^{b}
T5 (CONTROL)	13.2200±0.12 ^{b}	6.6333±0.11 ^{a}	95.567±0.12 ^{b}

*Means with the same superscript are not significantly different (p> 0.05)

Effect of coconut water extract and IBA on the survival percentage of cuttings of *S. roxburghii* G. Don

The study reveals that the stem cuttings of juvenile seedlings of *Shorea roxburghii* gave high rate of survival as most of the stem cuttings retain their freshness 4 weeks after planting with different concentrations of both IBA and coconut water. Untreated cuttings gave the best survival percentage (95.567±0.12), as this further support the work done by Aini *et al* (2010) who found that untreated cuttings also gave highest survival percentage and best rooting percentage in *Gonystylus bancanus*. Gbadamosi and Sulaiman (2012) also confirmed that coconut water significantly enhanced the viability and shooting in *Irvingia gabonensis.*

Effect of coconut water extract and IBA on the sprout count of cuttings of *S. roxburghii* G. Don

The number of sprouts gave a higher indication. In a study conducted by Akinyele *et al*, 2020, it was observed that IBA was less effective at inducing the formation of callus formation especially at high concentration. This report indicates that the use of synthetic growth regulators should be reduced.

Effect of coconut water extract and IBA on the root length and number of roots on cuttings of *S.roxburghii*

The number and length of the roots also indicate higher value in coconut water though the control showed little variation. In this study the maximum number of roots was observed in the treated cuttings with coconut water extract (14.4467±0.014) as compared to other treated with IBA and untreated cuttings. This study is in line with the findings of Brintha and Harris (2016) where coconut treated cuttings had a significant effect on the number of roots in *Ixora coccinea.* Coconut water increased the length of roots in this study significantly at p<0.05. this results confirms the investigation of Muhammad *et al* 2015 where the root length of potato increased significantly due to application of coconut water extract at 3 months

CONCLUSION

This study has indicated that macro-propagation techniques could be utilized to rapidly enhance the rooting ability of *Shorea roxburghii*. It was concluded that the sprouting, rooting performance and percentage survival of *S. roxburghii* stem cuttings performed better with coconut water extract as compared with those treated with Indole butyric acid (IBA) at different concentration levels.

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Pre-treatment effects on seed germination of *Faidherbia albida* (Del. a. Chev)

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ABSTRACT

This study assesses the effect of different pre-treatments (hot and cold water, mechanical scarification and Tetraoxosulphate (VI) acid (H_2SO_4)) treatments on early germination of *Faidherbia albida* seeds. The seeds were soaked in cold water for 24 hours and hot water at varying time interval, scarified at the helium with file, and soaked at different time interval in concentrated (H_2SO_4) acid. The result of various pre-treatments showed that they all had uniform germination percentage of 100% while seeds soaked in (H_2SO_4) for 15 min and 10 min had the highest germination value (GV) of 65.25 and 65.00 respectively, followed by 15 mins soaking in hot water (47.14GV) and the least germination value was recorded in seeds scarified mechanically (33.31 GV). Analysis of Variance (ANOVA) revealed that there was no significant difference in the treatments. Although, seeds treated with H_2SO_4, at 15 min and 10 min had the best performance in germination value compared with other treatments, but due to economic reason (cost of purchasing the acid) among others, hot water treatment for 15 min is recommended.

Keywords: Pre-treatment, germination value, seed quality, *Faidherbia albida* and peak value.

INTRODUCTION

Faidherbia is a genus of leguminous plants containing one species, *Faidherbia albida*, which was formerly widely included in the genus *Acacia* as *Acacia albida*. The species is native to Africa, its common name is apple-ring acacia, their circular, indehiscent seed pods resemble apple rings (Michael, 2010). This species has been known as *Acacia albida* for a long time. It is a thorny tree growing up to 6–30m (20–98 ft) tall and 2m (6.6 ft) in trunk diameter. Its deep-penetrating tap root makes it highly resistant to drought. The bark is grey, and fissured when old. In Southern Africa it is absent throughout most of the territory, avoiding dry and upland areas or areas of winter rainfall, but occurs along the floodplains of the Zambezi and Limpopo, in Kruger National Park, Pongoland, around Gaberone, in the northern Okavango, the Caprivi Strip, Kakaoveld, western Gaza and Maputo Province (Armstrong, 2015).

Faidherbia albida is important for raising bees, since its flowers provide bee forage at the close of the rainy season, the seed pods are used for raising livestock, are used as camel fodder in Nigeria, and are eaten by stock and game in Southern Africa (Bramm, 1997). They are relished by elephant, antelope, buffalo, baboons and various browsers and grazers, though strangely ignored by warthog and zebra (Kevin, 1990). The wood is used for canoes, mortars, and pestles and the bark is pounded in Nigeria and used as a packing material on pack animals. Ashes of the wood are used in making soap and as a depilatory and tanning agent for hides. The wood is used for carving; the thorny branches useful for a natural barbed fence, pods and foliage are highly regarded as livestock fodder. Some 90% of Senegalese farmers interviewed by Felker (1981) collected, stored, and rationed Acacia albida pods to livestock. It is valued in agroforestry as it fixes nitrogen, and a high yield has been achieved in at least one test plot of maize crops grown amongst the trees at a density of 100 to 25 tree per hectare (Bayala, 2010). According to a 2018 article by the Guardian, monocultures of this species are popular in parts of Niger, where it is known as gao in Hausa, to use for intercropping (MacLean, 2018). It is also used for erosion control. Its value as an agroforestry tree larges partially in the fact that the tree drops its leaves during the rainy season, and therefore does not compete with crops for sunlight (Becking, 2020). An extract is used to treat ocular infections in farm animals, the bark is used in traditional medicine in Southern Africa, and Niger (MacLean, 2018).

F. albida is hard seeded which produces seeds with tough and hard seed coat (Connor, 2009). This condition does not encourage even germination but rather results in erratic germination of seeds (Alderete-Chavez et al., 2011). To achieve rapid and synchronous germination artificially, therefore, the seeds must be subjected to some physical or chemical treatment (Islam *et al*., 2009) thus the need to investigate different pre-sowing treatments which can best enhance germination (Butola and Bedola, 2004). Studies by Anonymous (1998), Connor (2008) and Asiedu et al. (2011) suggested treatment of seeds with boiling water and scarification with 97% sulphuric acid to enhance germination. Several other pre-sowing treatments have been suggested to enhance germination in hard seeded seeds. These include gibberellic acid, potassium nitrate (Alves *et al.*, 2000), succinic acid (Ghadiri and Torshiz, 2000); HCl, nitric acid, boric acid, acetic acid, ethanol, methanol, benzene, xylene (Idu et al., 2007); thiourea, benzyl adenine (Schmidt, 2000), among others.

It has been noted by Orwa *et al.* (2009) and Asiedu *et al.* (2011) that very little work has been done on the plant thus the need to conduct further study to determine the maximum number of seeds which can germinate under optimum conditions (Willan, 1987). This experiment was thus conducted to investigate the effect of some pre-sowing treatments on the germination of seeds of *F. albida*.

MATERIALS AND METHODS

Matured fruits of *F. albida* were collected from Ogbomoso area of Oyo State, and seeds were extracted from the pods. Washed and sterilized river sand was filled into perforated plastic trays (30cm X 12cm) for germination investigation under mist propagator chamber. The experiment was subjected to 10 pre-germination treatments that consist of mechanical scarification, cold (24 hours), hot water (soaked in for 3min, 5min, 10min and 15min) treatment and acid (soaked in for 3min, 5min, 10min and 15min) treatment. Mechanical scarification involved filing at the micropyle end round the circumference. All the treated seeds (500 seeds) were sown in perforated plastic germination trays under a mist propagator chamber in a Completely Randomized Design (CRD). The geminated seeds were monitored and data collected were analyzed using descriptive statistics and Analysis of Variance (ANOVA).

Germination assessment: The effects of pre-sowing treatment were assessed by daily counting of number of germinated seeds. Germinated seeds were counted and removed from the date of sowing until there was no more germination. A seed was considered to have germinated when the tip of the radicle emerged free of the seed coat (Auld *et al.*, 1988). Daily germination percentage was summed up to obtain cumulative germination on each assessment.

Germination period was determined as the number of days from first observed germination to where there was no more germination but energy period was arbitrarily defined in 12 days (Willan, 1993). Germination pattern was also determined by number of seeds that germinate at the different days after sowing (Viswanath *et al.*, 2002).

Germination energy defined as the percentage by number of seeds in a given sample which germinate within a definite period such as 7-14 days under optimum or stated condition (Willan, 1987) was determined. Germination energy is also a measure of the speed of germination and hence, a measure of the vigour of seedlings (Willan, 1993). In addition, germination value which is a composite value that combines both germination speed and total germination was also determined. Germination value is an objective means of evaluating results of a germination test and is calculated using the formula proposed by Hartmann *et al.* (1997) as follows:

GV = MDG X PV

Where:

GV = Germination value

(MDG) = (Final) Mean daily germination

PV = Peak value mean daily germination

Total germination is expressed as Mean Daily Germination (MDG), calculated as the cumulative percentage of full seed germination at the end of the test divided by the number of days from sowing to the end of test period. Speed of germination was determined and expressed as peak Value, which is the maximum mean germination reached at any time during the period of the test (Willan, 1993).

Table 1: Various Pre-germination treatments and the methodology involved in pretreating *F. albida*

S/N	Treatment	Methodology
T1	Mechanical Scarification	Scarified at the helium
T2	Cold Water (24 hours)	Seeds soaked in cold water for 24 hours at room
T3	Hot water (60^0)	temperature
T4	Hot water (60^0)	Seeds soaked in hot water for 3 minutes
T5	Hot water (60^0)	Seeds soaked in hot water for 5 minutes
T6	Hot water (60^0)	Seeds soaked in hot water for 10 minutes
T7	Concentrated Acid	Seeds soaked in hot water for 15 minutes
T8	Concentrated Acid	Seeds soaked in concentrated H2SO4 for 3
T9	Concentrated Acid	minutes
T10	Concentrated Acid	Seeds soaked in concentrated H2SO4 for 5
		minutes
		Seeds soaked in concentrated H2SO4 for 10
		minutes
		Seeds soaked in concentrated H2SO4 for 15
		minutes

RESULTS AND DISCUSSION

The result revealed that the treatments had uniform 100% germination percentage. Seeds soaked in concentrated Tetraoxosulphate (VI) acid (H_2SO_4) for 10 and 15 minutes had the highest peak value 17.40 and 17.33 respectively as well as germination value of 65.25 and 65.00 respectively followed by hot water treatment with peak value of 12.57 and germination value of 47.14 while the least value was recorded in mechanical scarification with peak value of 9.33 and germination value of 33.31 (Table 2). Analysis of Variance (ANOVA) revealed that there were no significant differences in all the treatments (Table 3).

Table 2: Comparison of Various Pre-treatment and germination value of *F. albida* seeds

Treatment	Germination percentage (%)	Peak Value (PV)	Mean Daily Germination (MDG)	Germination Value (GV) = PV X MDG
T1	100	9.33	3.57	33.31
T2	100	12.01	3.75	45.04
T3	100	10.88	3.75	40.80
T4	100	10.63	3.75	39.86
T5	100	9.39	3.57	33.52
T6	100	12.57	3.75	47.14
T7	100	10.90	3.75	40.88
T8	100	11.13	3.33	37.06
T9	100	17.33	3.75	65.00
T10	100	17.40	3.75	65.25

Peak Value (PV) = Cumulative percentage of total seed germination divided by number of days
Mean Daily Germination (MDG) = Cumulative percentage of total seed germination divided by peak value
Germination Value (GV) = Mean Daily Germination multiplied by Peak Value

Table 3: Analysis of Variance (ANOVA) for the germination of *F. albida* under different pre-treatment

SV	DF	SS	MS	Fcal	Ftab
Treatment	10	0.59	0.058	1.72	1.83^{ns}
Error	154	5.19	0.034		
Total	164	5.78			

ns- not significant (p>0.05)

CONCLUSION

F. albida seeds are glossy due to the presence of wax in the seed coat which prevents easy penetration of water. Mechanical scarification treatment in the study had least performance while acid treatment had the highest performance. Therefore, in order to enhance optimum and uniform germination as well as, uniform seedling production, soaking of *F. albida* seeds in concentrated H_2SO_4 for 15 min is recommended but considering the cost of acid, hot water treatment can be considered since it performed better after the acid treatment. This will definitely facilitate the availability of seedlings for reforestation and agroforestry programs on sustainable basis.

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Manufacturing of wood ductile board from *Chasmanthera welwitschii* (Troupin).

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ABSTRACT

This research was to investigate the potential of *Chasmanthera welwitschii* fibre for the production of wood plastic board by making use of low-density polyethylene (recycled pure water sachet) as the board binder. The aim was to determine the effect of mixing ratio and board density on the dimensional stability together with the strength properties of the board produced. Eighteen boards were produced at mixing ratio of 1:1 and 2:1 (Resin to Fibre) with board densities of 300 kgm^{-3}, 400 kg m^{-3}, and 500 kg m^{-3} (each has three replicates). The boards produced were subjected to mechanical properties test, modulus of rupture, modulus of elasticity test. The result revealed that board produced from mixing ratio 1:1 (Resin to Fibre) and board density 500 kgm^3 was more dimensionally stable having the least mean value (5.6900E± 658.73354) in selected physical properties test and highest mean value in all the mechanical properties tested. The mixing ratio and board density has significant effect on the dimensional stability of the board. Increase in mixing ratio and board density resulted to improved dimensional stability and better strength properties of the board produced.

Keywords: Plastic board, Board binder, Board density, Mixing ratio, Dimensional stability.

INTRODUCTION

Wood plastic board is an engineered product formed by breaking down hardwood or softwood residuals into wood fibres, often in a defibrator, combining it with wax and a binder and forming panels by applying temperature and pressure (Spence, 2005). Fibre boards are classified based on density, a fibre board with density above 800 kgm^3 is classified as high density fibre board and a fiber board with density below 500 kgm^3 classified as wood plastic composite board (ASTM, 1978). Types of fibre board in order of increasing density include particle board, medium density fibre board (MDF) and hardwood density fibre board. It is used to form dashboards, rear parcel shelves, and inner door shells. These pieces are usually covered with skin foil or fabric such as cloth or leather. MDF has also replaced thin plywood and wet process hardboard in the production of molded and flush door skin (Kzysik *et al*., 1999).

Production of MDF and high density fibre board using formaldehyde has raised a lot of concern as it is very essential to use more friendly chemicals. Binding of the board can be improved upon during hot pressing by components that are part of the ligno-cellulosic material (Back, 1991, Bouajila *et al*., 2005). Paraffin wax is always added in small quantity to improve the poor water resistance. Fiber boards produced using annual plant materials and agricultural wastes have been reported to have poor water – resistant properties than wood (Ye x p, 2007). Recently, improvement has taken place in the MDF industry because MDF production has increased greatly. This research was carried out to produce wood plastic board from *Chasmanthera welwitschii* fibre using low density poly-ethylene so as to determine the effect of mixing ratios and board density on physical properties of the board produced.

MATERIALS AND METHODS

Chasmanthera welwitschii used for the research was collected from Akinyele cattle market, Ibadan. The recycled pure water sachet was bought from Aleshinloye market, Ibadan, Oyo State. The mould for the board production was constructed by metal fabricators at Ekotedo, Dugbe Area, Ibadan. *Chasmanthera welwitschii* was sun dried for two weeks precisely, after which it was mechanically fiberized into required sizes using electrically powered grinding machine and it was sieved with 4 mm wire mesh. The quantity of the materials used for the production of the fibre board of size (200 x 200 x 10) mm was calculated based on the mixing ratio of the component comprising the mass of the fibre board. The required quantity of *Chasmanthera welwitschii* and the recycled pure water sachet to be used were poured into a plastic bowl and then mixed together thoroughly after which it was blended together in an electrically powered blending machine. The mixture was put inside the mould to form the mat. The mat was taken to hydraulic hot press for composite production. Mould (200 x 200x 10) mm made with aluminum frame was coated with engine oil to prevent sticking of the formed fibre board on the mould. The mould containing the mixture of fibre and adhesive was taken to the press and subjected to pressure of 18psi and temperature of 2000 c for 15min.The boards produced were trimmed and cut into test samples using cross cutting machine and kept under a controlled laboratory environment prior to testing.

Test for physical properties:

Water absorption (W.A %): A Test sample with dimension (50 x 50) mm was used for the test. The initial weight of the boards was recorded using weighing balance before immersion in water. The final weights of the board were also recorded after 24 hours of soaking in water (Fuwape 1995).

$$\mathrm{WA} = \left(\frac{W_2 - W_1}{W_1}\right) \times 100$$

Where: W1= Initial weight (g), W2= Final weight (g)

Thickness swelling test (T.S %): Test samples of dimension (50 x 50) mm were placed in cold water at 250C. The initial thicknesses of the boards were taken using veneer caliper before the immersion in water. The final thickness of the boards was recorded after 24 and 48 hours respectively (Fuwape, 1995).

$$\mathrm{TS} = \left(\frac{T_2 - T_1}{T_1}\right) \times 100$$

Where: T1=Initial thickness (mm), T2=Final thickness (mm)

Test for mechanical properties:

The mechanical property determined were modulus of Rupture (MOR) and Modulus of Elasticity *(MOE). Internal Bonding Strength:* Internal bonding strength is also known as the tensile strength perpendicular to the surface. It provides measure of how well the panel is glued together. It was determined using three conditioned specimens of 50 mm x 50 mm from each composite board. Each panel was cut to width of 50mm, thickness 4mm, and length of 50mm for Internal bonding in accordance with INSTRON, 3369. The length grip of the machine with the material is at a distance of 10mm.

$$\text{IB} = \frac{P_s}{bl}$$

Where: IB = Internal bonding strength (pascal), Ps = rupture load (kilogram force), b = width (centimeter) and L = length (centimetre).

Modulus of rupture (MOR): Modulus of rupture is a parameter for measuring bending strength of non-wood materials. It measures the stress equivalence in the extreme fibres of the specimen (panshin and Dezeeulo 1980). Modulus of rupture is the maximum bending strength of stalks. To test for this, Hunfield tensiometer was used. Test samples were cut into dimension 195 × 50 thickness according to British standard, 1989. This was carried out by mounting the test samples one by one on the machine and the load was applied at the centre with the aid of an electromechanical motor till the point where failure occurs. The recording of the ultimate failure load (p) was estimated on the mercury meter.

The point of failure is the maximum Load (p). Modulus of Rupture (MOR) was then calculated by the formula.

$$\text{MOR} = \frac{3PL}{2bh^2}$$

Where: MOR = modulus of rupture (N/mm^2), P= Failing load, L= Span between centers of support (mm), B= Width of specimen (mm), h= Slope from the graph.

Modulus of elasticity (MOE): Modulus of elasticity is the ability of material to regain its original shape and size after being stressed (panshin and Dezeewo 1980). The modulus of elasticity was calculated from the load deflection graph during the Modulus of Rupture on (MOR). While the panel's stiffness (MOE) was determined from the bending test performed on each specimen and calculated using the formula:

$$\text{MOE} = \frac{3PL^3}{4bd3H}$$

Where P= Failing load, L= Span between centers of support (mm), B= Width of specimen (mm), h= Slope from the graph

RESULTS AND DISCUSSION

From Table 1, it could be observed that the mean values for thickness swelling ranged from 0.072% to 0.188% at 24 hrs and 0.161% to 0.289% at 48hrs while the mean values for water absorption ranges from 0.985 % to 2.079 % at 24 hrs and 2.33 % to 3.805 % at different board densities of 300 kg/m^{-3}, 400 kg m^{-3}, 500 kg m^{-3} using mixing ratio of 1:1 and 2:1 (binder/fibre). From the above result it was observed that the lowest mean of thickness swelling was obtained from the mixing ratio of 1:1 and board density of 300 kgm^{-3} with mean value of 0.0736±0.0326 at 24 hrs of immersion. While for the water absorption the lowest mean was obtained from board density of 300 kg m^{-3} and mixing ratio of 2:1 with the mean value of 0.985±0.088 at 24 hrs of immersion. As the mixing ratio (binder/fibre) increases from 1:1 to 2:1 for the board density of 300kgm^{-3} the water absorption rate decreases.

Table1: Mean value of physical properties of wood plastic board produced from *Chasmanthera welwitschii*

Board density (kg/m^3)	B/F	W.A (%) 24HRS	W.A (%) 48HRS	T.S(%) 24HRS	T.S(%) 48HRS
300	1.1	1.366±0.678	2.994±0.410	0.072±0.033	0.161±0.084
300	2.1	0.985±0.088	3.865±0.016	0.149±0.035	0.601±0.195
400	1.1	2.079±0.324	3.261±0.442	0.117±0.012	0.188±0.046
400	2.1	1.168±1.475	2.333±0.954	0.101±0.014	0.201±0.027
500	1.1	2.062±0.825	3.343±0.954	0.101±0.049	0.205±0.007
500	2.1	1.086±0.261	2.615±0.146	0.188±0.0456	0.289±0.065

B/F = Binder to Fibre, M.R-mixing ratio, W.A-water absorption rate, T.S-thickness swelling.
From Table 2, the mechanical strength of the selected mechanical (MOR, MOE and IB) properties was obtained at different mixing ratios and densities. For MOR board density of 500kgm-3give the highest mean value with the means value of 6.219±0.238, the board of 300kgm-3 with the mean value of 8.30E2±180.58273 gives highest mean value for MOE, while for IB it was obtained from the board density of 500 kg m^{-3} with mean value of 5.6910E±668.73354 all at the mixing ratio 1:1. This shows that as the board density increases the MOR and IB increases.

Table 2: Mean values of mechanical properties of wood plastic board produced from C*hasmanthera welwitschii*

Board density (kg/m^3)	L/B	MOR (N/mm^2)	MOE (N/mm^2)	IB (m)
300	1.1	5.843±1.178	8.3079E2±180.58273	1.6557E3±359.98758
300	2.1	4.061±0.435	6.5948E2±3.71482	1.3149E3±6.99552
400	1.1	5.676±5.0191	5.3201E2±302.50493	1.0583E3±720.14064
400	2.1	5.934±1.728	1.0902E3±238.77054	2.1744E3±479.03837
500	1.1	6.219±0.238	2.8761E2±329.26595	5.6910E2±668.73354
500	2.1	5.519±0.797	5.1412E2±150.71466	1.0234E3±701.9273

MOE = Modulus of Elasticity, MOR = Modulus of Rupture, IB = Internal Bond. L/B = fiber to nylon (mixing ratio)

CONCLUSION AND RECOMMENDATIONS

It has been clearly shown that wood plastic board is feasible from *Chasmanthera welwitschii* fibre when using polyethylene (recycled pure water sachet) as binder. The result also shows that mixing ratio and density has effect on the dimensional stability of the produced board as it was observed. Board with mixing ratio 1:1 and density of 300g/dm^3 has the lowest thickness swelling while board with 2:1 mixing ratio and density of 300g/dm^3 has the lowest rate of water absorption so it can be utilized in light constructions. On the basis of mechanical stability, board density of 500Kg/m^3 and mixing ratio 1:1 has the best dimensional stability and high strength properties.

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Assessment Of Growth Performance Of Gum Arabic (*Acacia Species*) Seedling As Influenced By Sowing Depth In The Nursery

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ABSTRACT
The experiment was conducted at the Rubber Research Institute of Nigeria, Gum Arabic Sub-Station Gashua, Yobe (12^0 $46'^N$, Longitude 11^0 $00'^E$ and Altitude 360m above sea level) to assess the growth performance of *Acacia species* seedling as influenced by sowing depth. The experimental materials consisted of top soil, river sand, cow dung and polythene bags. Polythene bags measuring 7.5 cm x 20cm were filled with potting mixture consisting of top soil, river sand and cow dung in a ratio 2:2:1. The polythene bags were laid out in Randomized Complete Block Design (RCBD) replicated three times. Two seeds were sown per pot at a depth of 1cm, 2cm, 3cm and 4cm and were thinned to one seedling per pot. At 1 month after sowing (MAS), seedlings growth traits (height, stem diameter and number of primary) of *Acacia specie* were statistically similar regardless of sowing depth. However, at 2, 3 and 4 months after sowing (MAS), seedlings of *Acacia seyal* significantly gave superior seedling heights compared to *Acacia senegal*. Irrespective of growth stage *A. specie* seeds sown at 2cm depths in the nursery improved seedling growth performance considerably

Keywords: Gum Arabic, Nursery, Seedling, Sowing Depths, Potting Mixture.

INTRODUCTION
Gum arabic is the dried exudates obtained from stems and branches of *Acacia senegal* or closely rotated species that belongs to the family Fabaceae (Dorthe, 2000). In Nigeria, high concentrations of natural stands of *A. senegal* that produce grade one gum arabic are predominantly found in north eastern part of the country though the cultivated and some wild forms occur in North Western states from Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa down to North East especially around latitude 10^0 $30'^N$ to 12^0 $00'^N$ (FDA, 2002). The volume of international trade on gum arabic by 15 African producing nations stands at 58,086 tons in

2018 (Okoro, 2020). The author further alluded that Nigeria production figure for same year was estimated at 1,472 tons coming a distance third position after Sudan and Senegal which account for 54, 803 and 1, 499 tons, respectively. Gum arabic is unique among the natural hydrocolloids because of its extreme water solubility. It gives excellent stabilizing and emulsifying properties to manufactured products such as food, beverages and pharmaceuticals. It is tasteless, odourless and non-toxic (Anderson, 1993). Other gum arabic not permitted as food additive include *Acacia seyal*, *Acacia laeta* and C*ombretum nigricans*. They have a positive optical rotation and are mostly used in printing, lithography, cosmetics, textiles, adhesives and soaps (Anderson, 1993). The plant is also useful for afforestation of arid tracts with desertification problems, soil reclamation and wind breaks (Duke, 1981). The leaf litters of *A. species* form an excellent source of nitrogen and organic matter which help to improve soil structure and fertility and when in association with microbial symbionts restores soil N through nitrogen fixation (Ojiekpon *et al.*, 2007).
The success of any tree planting exercise, depends largely on the use of good seedlings stock. Raising vigorous seedlings for filed transplanting will attractive premium price owing to the demand for gum arabic at both local and international market. This study was therefore conducted to determine appropriate sowing depths suitable for growth of gum arabic seedlings in the nursery.

MATERIALS AND METHOD

The experiment was conducted at the main nursery of Rubber Research Institute of Nigeria Gum Arabic Sub-Station, Gashua, Yobe state (12^0 $45'^N$ 11^0 $00'^E$ and 360m above sea level) in the Sahel savanna ecological zone of Nigeria. The potting mixture used were top soil, river sand and cow dung in ratio 2:2:1. Small hand dibbler was used to make a proper hole (Samthoth *et al.* 2020) in each of the polythene bags and four definite sowing depth of 1cm, 2cm, 3cm and 4cm were determined using meter rule to sow the two *Acacia species* (*Acacia senegal* and *Acacia seyal*) seeds. The experiment was laid out in Randomized Complete Block Design (RCBD) replicated three times. The seeds of *A. species* were collected from the sub-station plantation, top soil was collected from gum arabic experimental farm, river sand was sourced from sand vendor while cow dung was obtained from cattle Fulani settlement around the Sub-Station. Polythene bags of size 7.5cm x 20cm were used for the study. Two seeds were sown and later thinned to one seedling per polythene bag. Seedlings were watered morning and evening for four months except on days with rainfall. The growth data (plant height, number of primary branches and stem diameter) were determined monthly starting from one month after sowing (MAS) for up to four months.

The data were subjected to analysis of variance. Fishers test was used to test for significant difference among treatment means as described by Snedecor and Cochran (1987). Treatment means were compared using Duncan's multiple range test (Duncan, 1955). The data were analyzed using the general liner model procedure of statistics analysis system software version (SAS Institute, 2000).

RESULTS AND DISCUSSION

At 1, 2 and 3 MAS, sowing depth 1, 2 and 3cm though statistically similar significantly increase seedlings height compared with 4cm depth that gave the shortest seedlings regardless of the sampling month Table 1.

Table 1: Seedling height of *Acacia species* as influenced by sowing depth in the nursery

Treatment	Months After Sowing			
	Seedling Height			
	1	2	3	4
Sowing Depth (cm) SD:				
1	13.94a	26.11a	34.78a	46.14ab
2	13.75a	26.28a	26.27a	53.66a
3	11.71a	22.57a	32.48a	41.96b
4	2.88b	14.20b	21.24b	33.60b
SE±	1.27	2.722	3.687	5.968
Significance	**	**	**	**
A. Species (SPP)				
A. Senegal	9.99	14.20b	17.71b	24.25b
A. Seyal	11.14	30.38a	44.65a	63.43a
SE±	0.094	1.925	2.592	4.219
Significance	NS	**	**	**
SD x SPP	NS	NS	NS	NS

Means followed by the same letter within a column of a treatment group are not significantly different statistically at 5% level of probability using DMTR **, significant at 5% level. NS not significant.

The increases in seedling height sown at depth 1, 2 and 3cm could be due to shallow sowing depth which gave rise to early emergence of *Acacia species* seeds which must have given the seedling growth an added advantage over the deepest seed sown at 4cm. The result collaborates the finding of Adeogum *et al.* (2012) who reported better seedling growth performance of Velvet tamarind (*Dialium guineense*) seeds at 3cm sowing depth compared with 4cm and 5cm depth.

At 2 and 3MAS, depths 1, 2 and 3 though similar statistically significantly increase stem diameter and number of primary branches of *A. species* Table 2 and 3.

Table 2: Stem diameter of *Acacia species* as influenced by sowing depth in the nursery.

Treatment	Months After Sowing			
	Stem Diameter (cm)			
	1	2	3	4
Sowing Depth (cm) SD:				
1	0.39	0.38a	0.49a	0.66ab
2	0.41	0.40a	052a	0.69a
3	0.52	0.38a	0.47a	0.60ab
4	0.10	0.22ab	0.25b	0.43b

SE±	0.137	0.025	0.044	0.075
Significance	NS	**	**	**
A. species (SPP):				
A. senegal	0.44	0.34	0.41	0.40b
A. seyal	0.64	13.35	15.92	17.58a
SE±	0.097	0.018	0.031	0.053
Significance	NS	NS	NS	**
SD x SPP	NS	NS	NS	NS

Means followed by the same letters within a column of a treatment group are not significantly different statistically at 5% probability using DMRT. * and ** significant at 5% level. NS not significant.

Table 3: Number of primary branches of *Acacia species* as influenced by sowing depth in the nursery

Treatment	**Months After Sowing**			
	Number of Primary Branches			
	1	**2**	**3**	**4**
Sowing Depth (cm) SD:				
1	1.48a	4.65	7.08a	13.17
2	1.67a	5.56	9.31a	17.6
3	0.67b	3.84	7.54ab	17.6
4	0.13b	3.46	4.87b	10.91
SE ±	0.251	0.874	1.086	3.112
Significance	**	NS	**	NS
A. species (SPP)				
A. senegal	1.84a	3.94	6.43	9.33b
A. seyal	0.13b	3.77	7.87	20.30a
SE ±	0.177	0.687	0.768	0.975
Significance	**	NS	NS	**
SD x SPP	NS	NS	NS	NS

Means followed by some letter within a column of a treatment group are not significantly different statistically at 5% probability using DMRT. ** significant at 5% level. NS not significant.

However, *A. seyal* produce wider stem diameter and higher number of primary branches than *A. senegal*. The superior growth performance achieved by *A. seyal* may be due varietal and genetic influence since the two species were subjected to the same treatment as early suggested by Fakuta and Ojiekpon, (2009) in quantitative genetic variation of gum arabic provenances.

CONCLUSION

Form the result obtained from this investigation, sowing *A. species* at 2cm depth considerably increased seedling height, stem diameter and number of primary branches irrespective of seedling age. However, the experiment needs to be repeated before recommendation can be made.

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Assessing the Impacts of Climate Change on Water Resources, Agricultural activities and Food Security in Zaria Local Government Area, Kaduna State

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ABSTRACT
Agricultural activities depend greatly on climate. Therefore, any change in climate can enhance or limit the capacity of agriculture to play its major role as supplier of food and industrial raw materials. The study therefore, assessed the impacts of climate change on water resources, agricultural activities and food security in Zaria LGA, Kaduna State. The study used both primary and secondary data. Structured questionnaire was used to collect primary data from 384 respondents who were purposively sampled. Rainfall and temperature data were collected from Institute for Agricultural Research, Zaria. Data were analyzed using descriptive statistics such as mean, percentages and presented in Tables. Results showed that mean annual evapo-transpiration (2230mm) exceeds mean annual rainfall (1053mm) indicating likelihood of surface and groundwater deficiency in the area. Result also showed that climate change have posed significant impacts on crop production and food security especially as it led to the reduction in food availability and access as perceived by 80% of the respondents. The study therefore, recommended the need for effective water harvesting and introduction of high yielding, early maturing and climate change resistant varieties of crops in the study area.

Keywords: Agricultural activities, Assess, climate change, Food security, Water Resources

INTRODUCTION
Generally, climate, water resources, biophysical and socio-economic systems (including agriculture and food systems) are mutually interconnected in such a way that slight change in one, leads to changes in the others (Abdullahi and Adeogun, 2014). Climate change has seriously disrupted the entire ecological system of the earth. It has already impacted areas such as ecology, health, agriculture, water resources and so on. These impacts are felt by both the developed and developing countries. Unfortunately, the developing countries suffer more due to their poor economic, social and political capacity to adequately cope. Climate change is defined as the long-term variations in weather patterns which poses severe repercussions for man and the environment. Climate change has been predicted to worsen the incidence of drought and desertification. This may lead to severe water stress for agriculture and serious impacts on food security particularly in the rural areas where farmers mostly depend on rain-fed agriculture for survival (Ayinde, Muchie and Olatunji, 2011).

Climate change has posed a significant impact on water resources potentials of many areas particularly in Northern Nigeria. It is gradually altering the hydro-climatic characteristics of different ecological regions. This has led to severe negative consequences on the availability of water resources in both rural and urban areas. Studies (Hassan, 2013; Vaughan & Lenton, 2011; Odjugo, 2010) have shown that an increase in solar radiation and temperature leads to potential increase in the amount of evapo-transpiration thereby causing the decrease in the amount of surface and underground water resources. This is particularly more pronounced during the dry season in Northern Nigeria when the whole environment looks dry and thirsty (Abdullahi and Adeogun, 2014).

Today, many parts of Northern Nigeria (Zaria inclusive), are experiencing multiple climate change impacts on water resources. These areas faces severe climate change and induced extreme weather events such as devastating flood, drought, drying up of rivers, poor water quality and ground water availability, distortion of precipitation patterns, among others. The compounding effects of climate change on water resources in these areas therefore have devastating impacts on ecosystems, communities (including economic and social) and severe effects on agricultural activities from planting to harvesting, and food security which have seriously threatened the peaceful co-existence of the region (Adishi, and Oluka, 2018).

In simple terms, food security means access to basic nutritious food. It refers to the availability of food and ability of one to access it. It means 'all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their food preferences and dietary needs for active and healthy life' (Kelechi & Vincent , 2022). A household becomes food-secure when the occupants do not live in hunger. Unfortunately, climate change affect food production as well as food availability of Northern Nigeria which is mostly climate dependent. Climate change has the potential of impacting on food safety especially on the incidence and prevalence of food borne diseases (Ikpe**,** Sawa, Ariko, Abdulhamid & Akpu (2022). It is also evidenced that climate change leads to potential changes in the nutritional quality of some foods like cereals and cassava. The concentration of proteins, vitamins and minerals in these crops is significantly reduced due to elevated carbon dioxide in the atmosphere. Climate change also poses a significant impact on the quality of drinking water which is a key element in the absorption of nutrients. It is also evidenced that, increased climate variability as well as increased frequency and intensity of extreme events will continue to affect crop production, stability of food supply, availability, access and utilization (Ayo, Amoshi and Suleiman, 2014).

Food production in Northern Nigeria is carried-out in both rainy and dry seasons. Crops such as maize, millet, sorghum, rice, groundnuts, tomatoes, onions, carrots, cucumber among others, are cultivated in the region. Most of agricultural production in this area is rain-fed (Ikpe**,** Sawa, Ariko, Abdulhamid & Akpu, 2022). Unfortunately, climate change-induced extreme events such as distortions in precipitation, devastating floods, prolonged dry spells, drying up of rivers and depletion of ground water sources which has severely affected water availability for food production in the area (Ayinde, Muchie and Olatunji, 2011). However, despite these prevailing challenges, there are paucity of research work on the impact of climate change on water resources, agricultural activities and food security. This paper therefore, assesses the impacts of climate change on water resources, agricultural activities and food security in Zaria Local Government Area (LGA) of Kaduna State. To achieve this, the following questions are raised:

i. What is the nature of water balance indices in Zaria LGA?
ii. What are the impacts of climate change on water resources in the study area?
iii. What are the impacts of climate change on agricultural activities and food security in

the study area?

MATERIALS AND METHODS

Zaria Local Government Area (LGA) is located between Latitudes 11° 0' and 11° 6' North and between Longitudes 7° 38' and 7° 48' East of the Greenwich meridian. The LGA has a Tropical Savanna Climate represented by Aw based on Köppen climate classification, with warm weather year-round, a wet season lasting from April to September, and a drier season from October to March. The climate in the area is divided into two: dry and rainy seasons. The dry season is usually from November to March and the temperatures recorded are within an average of 28°C towards the end of the dry season. The area is blessed with adequate rainfall and an abundance of fertile land for agriculture. Zaria has a mean rainfall of 1082m with a rain intensities raining between 25mm/hours and 125mm/hr. (Maiwada *et al.*, 2017). The predominant occupation of the area is agriculture. The LGA has a total population of 406, 990 (NPC, 2009).

The study used both primary and secondary sources of data. The primary data was collected through the use of structured questionnaire, while secondary data (climate data) was collected from the Institute for Agricultural Research (IAR), Zaria. Krejcie and Morgan's (1970) method of determining sample size, was used to select 384 respondents which formed the sample size for the study. In this case, respondents who were directly engaged in crop production among the seven (7) agriculturally active wards and who must have reached at least 30 years of age were purposively sampled. The data collected were analysed using descriptive statistics in form of mean, percentages and tables.

RESULTS AND DISCUSSIONS

The water balance indices of the study area are presented in Table 1.

Table 1: Water Balance Indices

Decadal mean	Rain (mm)	Evapotranspiration (mm)	Differences (mm)
1992 – 2001	1009.3	1999.68	990.38
2002 – 2011	1086.02	2199.96	1113.94
2012 – 2021	1063.95	2493.22	1429.27
Mean annual Total	**1053**	**2230.95**	**1177.95**

Source: IAR, Zaria

Table 1 show that the mean annual rainfall for the study period (1992 - 2021) was 1053 mm while the mean annual evapotranspiration data for the same period was 2230.95 mm. This indicates that the rate of evapotranspiration exceeds precipitation (rainfall). This is an indication of deficit in both surface and groundwater which might be exacerbated by the impact of climate change.

Table 2: Perception of the Impacts of Climate Change on Water Resources

Impacts of Climate change on Water	SD (%)	D (%)	U (%)	A (%)	SA (%)
Decrease in quantity/quality of water	17	12	5	32	34

Shrinking/drying up of surface water	14	8	2	24	52
Water related diseases	18	15	7	31	29
Increased frequency of drought/dry spell	31	22	3	20	24
Burden on women/children in search of water	12	11	5	34	38
Farmer/herder conflicts over scarce water	11	13	10	24	42
Wilting of crops due to water stress	11	14	5	34	36

Source: Field Survey, 2022

Table 2 show that 32% and 34% (66%) of the respondents had agreed and strongly agreed respectively that there was decrease in the quantity and quality of water resources in the study area; 24% and 52% (76%) agreed and strongly agreed respectively perceived the shrinking and drying up of surface water in the study area. This is particularly more pronounced during the prolonged dry season when everywhere looks dry and dusty. This scenario has serious impact on irrigation farming and other agricultural activities in the study area. Table 2 further shows that majority (60%) of the respondents opined that there was increasing water related diseases in the study area. This connotes that the area suffers from climate change exacerbated diseases such as cholera, diarrhea, dysentery and typhoid fever. More so, Table 2 further shows that majority of the respondents (72%) agreed that climate change induced water stress which has increased the burden on women and children who always roam around in search of water for domestic use. Table 2 also shows that majority (66%) of the respondents perceived increasing farmer/herder conflicts due to scarcity of water supply; while 70% indicated that climate change induced water stress have been causing partial drying of crops during the growing season. All these may have significant impacts on food security of the study area.

Table 3: Impacts of Climate Change on Crop Production and Food Security

Impacts of Climate change on Food	SD (%)	D (%)	U (%)	A (%)	SA (%)
Reduced food availability and access	16	14	4	32	48
Reduced nutritious quality of food	14	18	7	24	37
Food stability is severely hampered	13	21	6	38	22
Reduced fresh water availability	18	22	7	38	15
Prevalence of food-borne diseases	16	19	4	24	37
Frequent food spoilage after storage	21	22	4	18	35

Source: Field Survey, 2022

Table 3 indicates that 32% and 48% (80%) of the respondents agreed and strongly agreed respectively that climate change has significantly affected crop production, availability and access to food in the study area. This is exacerbated by climate change induced conflicts in wards such as Wucicciri, Dutsen Abba and Kufena. The people in these areas are forced to migrate to another area which leads to decrease in food availability and access or undernourishment. That climate change has significantly affected crop production in Zaria agree with the report of Ikpe**,** Sawa, Ariko, Abdulhamid & Akpu (2022) which reported that climate change has led to a decline in the yield of grain crops in Sokoto State thereby affecting the availability of food. Table 3 also shows that 61% of the respondents perceived that climate change has led to the reduction in the nutritious quality of food. Typical example of this, is the continuous rise in carbon dioxide level in the atmosphere which reduces plants nutrients and vitamins needed for human survival (Ikpe, 2021). Table 3 further shows that majority (60%) of the respondents agreed and strongly agreed that food stability is seriously hampered by the effects of climate change in the study area, which implies that food availability for human consumption is seriously affected by the impact of climate change.

More so, fresh water availability for domestic consumption has significantly reduced as shown in Table 3 (53%). This owes to the rapid drying up of surface water and depletion of groundwater particularly in the dry season. Table 3 further shows that majority (61%) of the respondents, perceived high prevalence of foodborne diseases in the study area. This is obvious as the rising temperature and increased precipitation promotes many foodborne disease like typhoid and cholera which are paramount in the area. Table 3 further shows that 53% of the respondents reported frequent food spoilage after storage. Increasing temperature and rainfall may promote pathogens proliferation and foodborne diseases outbreaks. Non-refrigerated foods are more susceptible to spoilage due to the impacts of climate change.

CONCLUSION

Based on the findings of the study, it is concluded that, mean annual evapo-transpiration exceeds mean annual rainfall, indicating likelihoods of surface and groundwater deficiencies in the study area. The study also concludes that climate change impacts had led to decrease in quantity and quality of water resources, increasing water related illnesses as well as climate change induced water stress. Climate change has also impacted on food security in that it led to reduction in food availability and access, reduction on nutritious quality of food and prevalence of foodborne diseases. Based on this, the study recommends the need for effective water harvesting particularly, during the rainy season to be used at the time of water deficiencies as well as the need for the introduction of high yielding, early maturing and climate change resistant varieties of crops to carter for food deficiencies in the area.

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Land use/Land volume equations of *Tectona grandis* plantation in Agudu forest reserve, Lafia, Nasarawa State, Nigeria

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ABSTRACT

The aim of this study is to determine land use/land cover change and develop volume models for *Tectona grandis* plantation in Agudu Forest Reserve, Agudu Village in Lafia Local Government Area, Nasarawa State, Middle Belt Zone, Nigeria, with a view to provide information for stakeholders in forestry for sustainable management. Three plots were randomly selected from different area of the whole plantation. Perimeter measurement for each plot were; Permanent Sample Plot 1 (PSP1) with size 30.6m by 27.3m contained 117 tress, Permanent Sample Plot 2 (PSP2) with size 30m by 21.6m had 99trees, while Temporary Sample Plot 3 (TSP 3) with size 22m by 26m had 76 trees. Six (6) plus trees were identified in each of the plots. The results indicated that the Models generated for tree volume estimation area highly significant at ($p<0.01$) and have a high coefficient of determination (R^2), Model equation six(6) was chosen to be the best model because it is highly significant and has the highest coefficient of determination (R^2) = 94.20 for the stand trees, while model equation two (2) was chosen to be the best equation because it is highly significant at ($p<0.01$) and has the highest coefficient of determination (R^2) = 99.8. All the models generated were adequate and are recommended for *Tectona grandis* volume assessment in the study area. The stand volume equations, which incorporated various tree growth variables, will enhance future yield prediction of the trees in the study areas since they provide quantitative basis for estimating stand growth parameters. It is believed that these models and volume prediction equations will enhance sound and informed management decisions and conservation measures for the remaining *Tectona grandis* stands.

INTRODUCTION

Forest plantations are increasingly important forest resources in the world; some forest plantations provide the bulk of the wood in their country like Australia, etc. (Evans, 2002).

Agudu forest reserve/plantation is a permanent sample plot (PSP), composed of pole sized trees of Teak (*Tectona grandis*), which covers a total area of 36,000Ha. (88954.781 Acre). For proper management of (PSPs), there is a need for the regular assessment of these resources. Land use practices affect the distribution and supply of soil nutrients by directly altering soil properties and by influencing biological transformations in the rooting zone. For instance, cultivation of forests diminishes the soil carbon (C) within a few years of initial conversion and substantially lowers mineral sable of nitrogen (N) Majaliwa, *et al*., (2010). Land use changes, especially cultivation of deforested land may rapidly diminish soil quality, as ecologically sensitive components of the forest ecosystem are not able to buffer the effects of agricultural practices. As a result, severe deterioration in soil quality may lead to a permanent degradation of land productivity (Islam, K.R. and R.R. Weil, 2000). Forest vegetation and land use /land cover changes have been defined as the spatial and structural changes in the form of forest degradation and depletion, reducing the forest density and species diversity and the extension of arable land and other land use types inside the natural cover after its disturbance.
The land use planning for sustainable future requires investigations into possible land use changes and the impact it has on ecological functions and processes at the local level (Zebisch*et al*., 2004). One of the most important land use changes is that the world's forests, grasslands and woodlands have declined, while the cropped land areas have expanded by a similar magnitude (Slayback, 2003).

MATERIALS AND METHODS

Study Location

The study was carried out in Agudu Teak (*Tectona grandis*) plantation, obi local government area, Nasarawa State, Lafia. Located between latitude 08°N and longitude 09°E. The total area coverage by *Tectona grandis* plantation is 36,000 h. (88954.781 Acre). Obi local government in Nasarawa State has five districts namely; Obi, Agwutashi, Agudu, Daddare, Riri and sub-divided into 10wards for administration convenience. The area is predominantly inhabited by Koro (Migili), Alago, Gwandara and other tribes like Eggon, Hausa, and Fulani. The loamy and clay soils in swampy and water logged areas are been used as FADAMA. The climate is characterized by warm and humid with two seasons namely dry and wet seasons. The raining season starts from April through November and dry season starts from part of November through March, with a mean annual rainfall of 1150 mm to 1550 mm, and a mean temperature range between 26°C and 30°, It has relative humidity of 60-80%and falls within the Guinea Savanna vegetation zone (Metrological Department, 2009).

Method of Data Collection

Perimeter measurement for each plot were; PSP1 30.6 m by 27.3 m, PSP2 30 m by 21.6 m, TSP3 22 m by 26m, selected using simple random sampling method from different parts of the whole plantation. Each sample plot contained Permanent sample plot 1 (PSP1) of 117 tress, Permanent sample plot 2 (PSP2) of 99 trees, Temporary sample plot 3 (TSP 3) of 76 trees. Sample trees planted in a 4 x 4 spacement were systematically numbered for easy enumeration using the following: girth tape, Haga altimeter, Writing materials, Permanent marker, Cutlass, camera and pegs.

Table 1 Models generated for tree volume estimation at Agudu Forest

s/n	Equations	N	R^2	R^2 (adjusted)	SEE	F	Sig	Double Watson
X	LogNV = 0.20 + 0.04LogMH + 1.62LogDbh	292	80.00	79.90	0.14	787.58	0.000**	1.49
1	logNV = -1.02 + 1.36logTH + 1.53logDbh + (-0.07FF	292	91.80	91.80	0.14	2385.00	0.000××	1.62
2	lnNV = -9.87+ 10.17lnTDia + 1.69lnBD + 0.46Fq	292	91.80	91.80	0.33	2387.00	0.000××	1.59
3	lnNV = 1.19 + 0.18lnCH + 1.92lnDBH	292	86.80	86.80	0.42	2103.00	0.000××	1.66
4	lnNV = 2.75 + 0.78lnDbh + 1.31lnDM	292	89.20	89.20	0.38	2638.00	0.000××	1.67
5	lnNV = 0.58 + 1.89lnDbh + 3.13lnDT + 1.50Fq	292	89.30	89.30	0.38	1777.00	0.000××	1.68
6	lnHV = -0.77 + 8.08DM + 0.81lnBA + 0.84FF	**292**	**94.20**	**94.20**	**0.28**	**3448.00**	**0.000××**	**1.61**
7	lnNV = -2.43 + 1.52lnDbh + 1.35lnTH	292	91.80	91.70	0.33	3548.00	0.000××	1.61
8	lnNV = -10.43+ (-0.00)lnCArea + 3.25lnTH	292	60.40	60.20	0.73	485.03	0.000××	1.68
9	lnNV = -8.40 + 1.81lnTH + 0.03BG	292	89.60	89.50	0.37	2735.00	0.000××	1.79
10	lnNV = -4.88 + 0.17lnCArea + 14.89DBH	292	80.70	80.70	0.51	1336.00	0.000××	1.77

Dbh = Diameter at breast height, BG = Basal girth, DM = Diameter at middle, DT = Diameter at top, TH = Total height, BA = Basal area,CArea = Crown area, NV = Newton's volume, FF = form factor, Fq = form quotient , CH= Crown Height

Result of models generated for tree volume estimation in Agudu Forest Reserve In Agudu Teak plantation 10 models were generated and 7 of the model prediction equations generated have negative intercepts (Table 1). This is as a result of the logarithmic transformation of the variables utilized in the models, thereby leading to value reduction vis-à-vis tilting of the variable values towards negativity. The standard error of estimate (SEE), which measures the overall predictive value of regression models and which is a common measure of goodness of fit in nonlinear regression models, with low value indicates better fit. In this study, the SEE of the models ranged between 0.14 and 0.51. These results suggest that all the models have good fit within the context of the field data. Comparing the 10 models tried in this study using the fit statistics, model 6, which is with diameter at the middle, basal area and form factor as the independent variable is the most appropriate (R^2 = 94.2, R^2- Adjusted = 94.2, SEE = 0.28 and F-ratio = 3448.00, Double Watson value = 1.61, significance = 0.000** highly significant at 1%P<0.01 level of probability. In other words, diameter at the middle is the best predictor of *Tectona grandis* stem volume among all the tested predictors.This may be due to the Newton's formula used in the estimation of the volume. Hence, more preference is given to diameter at the

s/n	Equations	N	R^2	R^2 (adjusted)	SEE	F	Sig	Double Watson
1	HV = -0.30+ 9.25BA + 0.02MeanMTH	292	99.7	99.7	0.02	35960.0	0.000**	1.46
2	HV = -0.26+ (-1.69)BD + 11.36BA + 0.03MeanTH	**292**	**99.8**	**99.8**	**0.02**	**41350.0**	**0.000****	**1.55**
3	logHV = -2.20+10.07BD+(-8.17)BA + 0.02MeanTH	292	99.1	99.1	0.03	9410.0	0.000**	1.62
4	LnHV = -5.05+23.18BD+(-18.82)BA+ 0.06MeanTH	292	99.1	99.1	0.06	9410.0	0.000**	1.62
5	LnHV = -5.05+ 23.18LogBD + (-18.82)BA + 0.06MeanTH	292	99.1	99.1	0.06	9410.0	0.000**	1.62

middle than those from base and top by having the highest (R^2 = 94.2) coefficient of determination (equation 6).

Table 2: Models generated for stump volume estimation in Agudu Forest
Dbh = Diameter at breast height, BG = Basal girth, BD=Basal diameter, DM = Diameter at middle, DT = Diameter at top, meanTH = Mean total height, BA = Basal area,CArea = Crown area, HV = Huber's volume, FF = form factor, Fq = form quotient.

In Agudu Teak plantation there are 46 stumps in permanent sample plot 1 (PSP1), 42 stumps in permanent sample plot 2 (PSP 2), 29 stumps in temporary sample plot 3 (TSP 3). 5 models were generated and all of the 5 model prediction equations generated have negative intercepts (Table 2). This is as a result of the logarithmic transformation of the variables utilized in the models, thereby leading to value reduction vis-à-vis tilting of the variable values towards negativity. In this study, the SEE of the models range between 0.02 and 0.06. These results suggest that all the models have good fit within the context of the field data. Comparing the 5 models tried in this study using the fit statistics, model 2, which is with basal diameter, basal area, and mean total height as the independent variable is the most appropriate (R^2 = 99.8, R^2-Adjusted = 99.8, SEE = 0.02 and F-ratio = 41350.0, Double Watson value = 1.55, significance = 0.000** highly significant at 1%P<0.01 level of probability. It is the most appropriate by having the highest (R^2 = 99.8) coefficient of determination (equation 2).

CONCLUSION

This project was carried out to know the volume estimated for each tree per plot and for each plot mean for exploitation. It is a known fact that the stand volume equations, which incorporated various tree growth variables, will enhance future yield prediction of the study area since they provide quantitative basis for estimating stand growth parameters. For instance, those growth variables that have very strong relationships, depicted by their high coefficient of determinations (R^2) and low standard error of estimate (SEE) with tree stem volume could be regarded as important determinants to be considered in stand volume assessment in Agudu Forest Reserve. The volume prediction equations provide the means through which the production potential of the existing stands can be estimated in the study area. It is believed that the equations obtained in this study will enhance sound and informed management decisions and conservation measures for the remaining stands.

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Effect of mixed substrate combinations on phytochemical levels in cultivated Oyster mushroom

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ABSTRACT

The nutritional and chemical compositions of mushroom contributes significantly to their medicinal values. The study assessed the effects of different substrates combination on the phytochemical compositions of Oyster mushroom (*Pleurotus ostreatus*) in Makurdi Local Government Area of Benue State, Nigeria. Sawdust and various agrowastes (cowpea waste, cassava peels, maize cobs, guinea corn husk, and rice bran) were proportionately mixed at varying combination to form different substrate treatments. Phytochemical analyses of harvested matured oyster mushrooms were determined following prescribed standards. The results of findings revealed that a percentage composition ranging between 0.56 and 2.76 % (tannin content), 6.0 and 24.0% (saponins), 9.0 and 18.0 % (flavonoid), 6.0 and 9.0% (alkaloid) and, 0.50 and 16.0% (steroids) which are within the tolerable and acceptable limits of WHO. In view of these, various agro wastes can be utilized as substrates and therefore reasonably combined to actualize the phytochemical levels required in the mushrooms which could be used as excellent food material and also for medicinal purposes.

INTRODUCTION

Pleurotus ostreatus, commonly known as Oyster mushroom is among the immense array of mushrooms with untapped new compounds (Kuo 2005; Guggenheim et al 2014; Duru*et al* 2019). It can be found in the wild, and can as well be cultivated using different wood and agro wastes. *P.ostreatus* is edible and has tough texture on mastication.Mushrooms are regarded as small medicinal factory which nature has provided for humans. However, Oyster mushroom is highly medicinal and rich in dietary fibre, proteins, macro and trace elements. Its phytochemical content has made it a special diet for the prevention and treatment of hyper-cholesterolemia (Duru *et al* 2019, Hossain *et al* 2003). Mshigeni and Chang(2000), reported that people in developing and developed nations should be encouraged to cultivate mushrooms in large scale and use them to address health challenges. Bayo and odiaka (2021) conducted a survey and discovered large varieties of mushrooms in the wild with no history of cultivation in Benue state,Nigeria. Overtime researchershave explored various importance of Oyster mushroom particularly as it relates to food (Duru*et al*., 2018, Adedayo, 2011, Kayode *et al* 2013), as well as health value(Okwulehie and Ogoke2013, Maria *et al* 2015, Duru 2017). Due to the to the abundance of farm wastes in Benue state Nigeria, the study assessed the influence of different substrates as it relates to the presence of phytochemicals in *P.ostreatus.*

MATERIALS AND METHODS

Cultivation, Inoculation and Phytochemical analyses

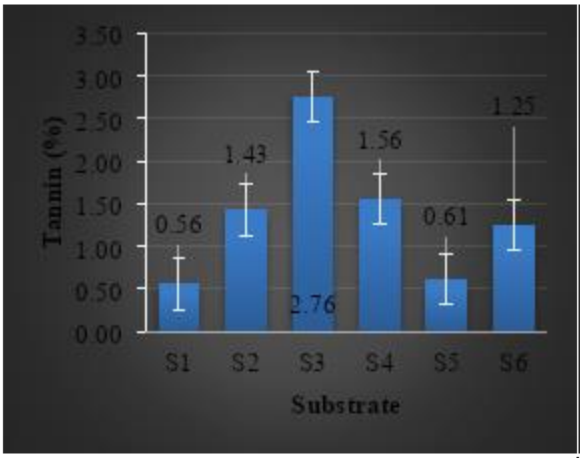
The substrates were collected from various mills in Makurdi Local Government Area of Benue state where these farm harvest processing takes place. The various mixed substrate combination includesS1: Sawdust. (control),S2: Sawdust / cowpea waste, S3: Sawdust / cassava peels, S4: Sawdust / Maize cobs, S5: Sawdust / Guinea corn huskS6: Sawdust / Rice bran. Other materials include spawn bottles of *Pleurotusostreatus* from Forestry research institute of Nigeria [FRIN], Ibadan.25 kilograms (25 kg) each of the selected substrates were weighed and composted for 30 days using lime (1%). The compost heaps were turned every three to five days. The substrates were pasteurized at 100^{o}C for 3 hours

The substrate bags were incubated and inoculated.The bags were exposed after primordia (pinhead) formation (35 days) and transferred to the fruiting room for subsequent fruit bodies' development. All bags were monitored daily for flushes of fruiting bodies.Matured fruiting bodies were harvested and the harvests were made across all substrate types in the course of the experiment andanalysed.

The tannin content was determined using the methods described by Kirk and Sawyer (1989), while the alkaloids and flavonoids were determined using the methods described by Trease and Evans (2004). Total saponins were extracted and yield determined by gravimetric method (AOAC, 1990).Qualitative tests and quantitative estimation of steroids was carried out using the methods of Edeoga*et al* (2005) and Madhu e*t al* (2016).

Results and Discussions

The experiment revealed the presence of several phytochemical compounds under investigation in various degrees. The tannin content ranged from 0.56 to 2.76 % (Fig. 1.). The content of saponins in the samples ranged from 6.0 to 24.0% (Fig. 2). Flavonoid and alkaloid contents ranged from 9.0 to 18.0 % and 6.0 to 9.0% respectively in all the samples (Fig. 3&5), while the steroids content ranged from 0.50 to 16.0% (Fig. 4). There was no trace of steroids in sawdust substrates being the control.



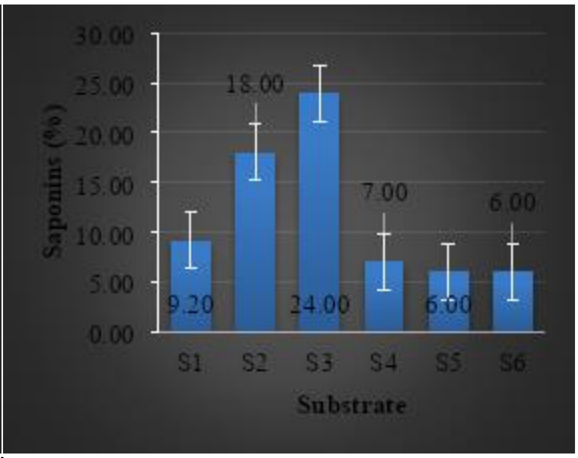
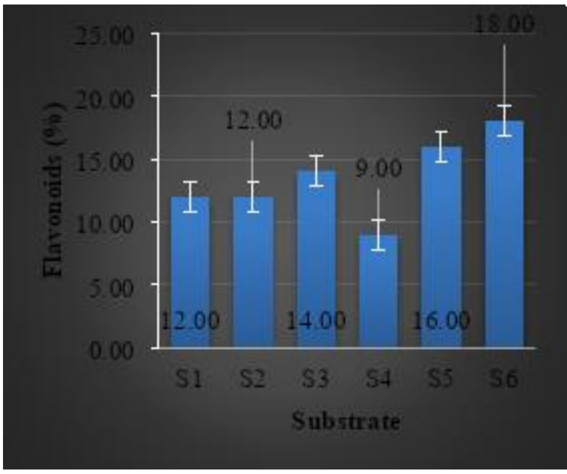


Fig. 1. Percentage composition of Tanins (mg/100g). Fig. 2. Percentage composition of Saponins (%)



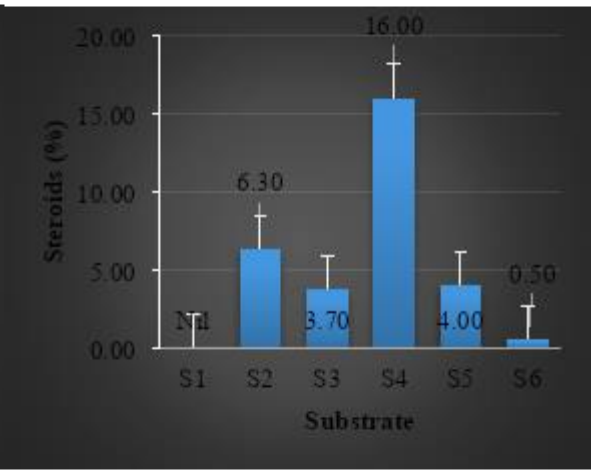


Fig. 3. Percentage composition of Flavonoids (%) Fig. 4. Percentage composition of Steroids (%)

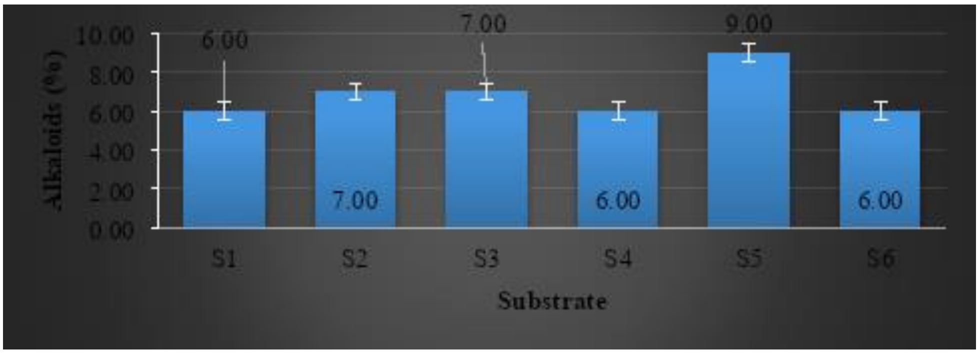


Fig. 5. Percentage composition of Alkaloids (%)

The phytochemical analysis of the cultivated *P. ostreatus* using proportional mixture of substrates revealed the presence of major bioactive constituents including flavonoids, tannins, saponins steroids and alkaloids as similarly reported by Lindequist*et al.* (2005), Iwalokun*et al.*, (2007), Kinge*et al.*, (2016) and Nsoh*et al.*, (2022). However, alkaloid was absent in the phytochemical analysis of mushrooms as documented by the above-mentioned research scientists. This observation can be attributed to the variation in substrate materials used in the cultivation of the mushroom which is in tandem with the assertion of Kinge*et al.,* (2016) and Muswati*et al.,* (2022) that the concentration and type of bioactive component varied depending on the substrate material used and the type of medicinal plant supplement. Accordingly, substrate mixture has significant influence on mushroom performance and productivity (Kinge*et al.,* 2016; Nsoh*et al.,* 2022; Muswati*et al.,* 2022) and it can also help in the optimization of the compositional features including water holding capacity, increased substrate structure, porosity that improves water penetration and gaseous exchange (Muswati*et al.,* 2022).

It has been asserted that the nutritional and chemical compositions of mushroom play significant roles in their medicinal values (Lindequist*et al*., 2005). The bioactive compositional constituents present in edible mushrooms are essential in promoting human health. For instance, saponins is made up of large family of related compounds reported to have a wide range of pharmaceutical properties, such as anti-malarial, anti-cancer, anti-inflammatory and anti-diabetic effects which are significant in the management of diabetes and inflammation related diseases values (Lindequist*et al*., 2005). Also, the antioxidant phenolic compounds present in mushroom possess a wide spectrum of medicinal properties such as anti-cancer and anti-inflammatory useful for the management of oxidative stress induced diseases (Pandimeena*et al*., 2015).

The saponin contents of the mushrooms were significantly higher than in the study of Afiukwa*et al* (2013). The values obtained for saponins in this study are however within the WHO maximumpermissible limit of (48.50mg/100g).The results suggest that these mushrooms could be safefor consumption and the substrates used in no way endanger the health values of the food material.The flavonoid compositions of this edible mushrooms are significantly lower thanthe tolerable limit (52.02mg/100g) (WHO, 2003) indicating that the mushrooms are equallysafe and could be good sources of anti-oxidants that boosts body immunity. The Tannin and Alkaloids contentsas revealed in this study are higher than those reported by Onuegbu*et al.,* (2020) whose ranges of values are between 0.14 and 0.52 %Tannin content and 1.66 to 2.37% for Alkaloids. This study has further revealed that the various substrates under investigation have substantial influence on the content of phytochemicals in the mushrooms grown. With the exception of steroids that was not found in mushrooms grown in pure sawdust substrates, all the five phytochemicals were found in significant amounts. Sawdust /cassava peels substrates gave highest tannin and saponins values, while sawdust/rice bran, sawdust/maize cobs and sawdust/guineacorn waste substrates, yielded highest values of flavonoids, steroids and alkaloids respectively.

CONCLUSION

The study was conducted to determine the effects of different substrates on phytochemical on oyster mushroom in Benue State, Nigeria. The results of findings revealed that mixed substrate combinations have significant effects on phytochemical constituents, particularly of *P. ostreatus* (Oyster mushroom). This has further validated the established facts that the nutritional and chemical compositions of mushroom are responsible for their medicinal values.

The phytochemical compositions in terms of flavonoids, tannins and alkaloids as indicated in the study are within WHO tolerable limits. Consequently, these substrates can therefore be reasonably combined to actualize the phytochemical levels required in the mushrooms which could be used as excellent food material and also for medicinal purposes.

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Devastating Effects of Anthropogenic Activities on Nigerian Environment: A Case Study of Atakunmosa Local Government Area of Osun State, Nigeria

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ABSTRACT

Human play a very prominent role in a day to day environmental dynamics. The devastating effect of anthropogenic activities on Atakunmosa local government land scape was examined. Consequently, the effects of these mining activities in the environment were identified. An illegal mining activity of gold was discussed and their negative effect on the environment. The destruction of means of livelihood is worrisome as a result of uncoordinated activities of illegal artisan miners in the area. Strategies for effective environmental conservation need to be enforced like regulation of illegal mining and petroleum exploitation and also mass enlightenment of the public on environmental protection programmes in virtually all the local government areas in the country.

Keyword: Anthropogenic, Environment, Livelihood, Destructive, Conservation

INTRODUCTION

Environment describes all the physical, biological, social and cultural factors, which influence the wellbeing of an organism (Hammed T. B., 2013). Sadly, the natural resources we get from the environment are continuously being changed by man through his irrational exploitation with little or no desire for replacement. In order for man to survive, he has to delve into activities which affect the environment; like, mineral exploitation, domestic and industrial exploration e.t.c and resulting consequence of all these is the destruction of the natural habitat of both faunas and flora species. Gold is found native in association with other minerals. For instance, Bagdasarou and Simakov (1988) reported that native gold from the Karehakola region in the former USSR contained 4.2 - 5.4 % silver. The Itagunmodi gold ore in Atakumosa Local

Government Area of Osun State is a mixture of minerals (zirconite, ilmenite, cassiterite and monazite) and gangues. Other types of gold ores include but not limited to the following: chalcopyrite, pyrite, sylvanite, calaverite, petzite, auriferrous and argentiferrous ores (Eligwe, *et al.*, 1993). In view of the various challenges of deforestation, and illegal felling of trees, there is the need for conserving the forest and its content. Although different countries have different ways of conserving their forest from harmful human activities, the objective anywhere is to reduce the possibility of desertification. In Igun Ijesha gold city, the community depend on the forest and all that they can obtain from it for their livelihood

MATERIALS AND METHODS

Location

This study was conducted in Itagunmodi, located in Atakunmosa West Local Government of Osun State (Figure 1). Itagunmodi town (formerly known as Igbo Nla) is dwarfed by an imposing background of a vast Ora Mountain; on latitude (DMS) 7031’60’’, longitude (DMS) 4039’0’’ and altitude (meters) 347 the time zone is east (est). It has an area of 577 km² and a population of 68,643 at the 2006 census.

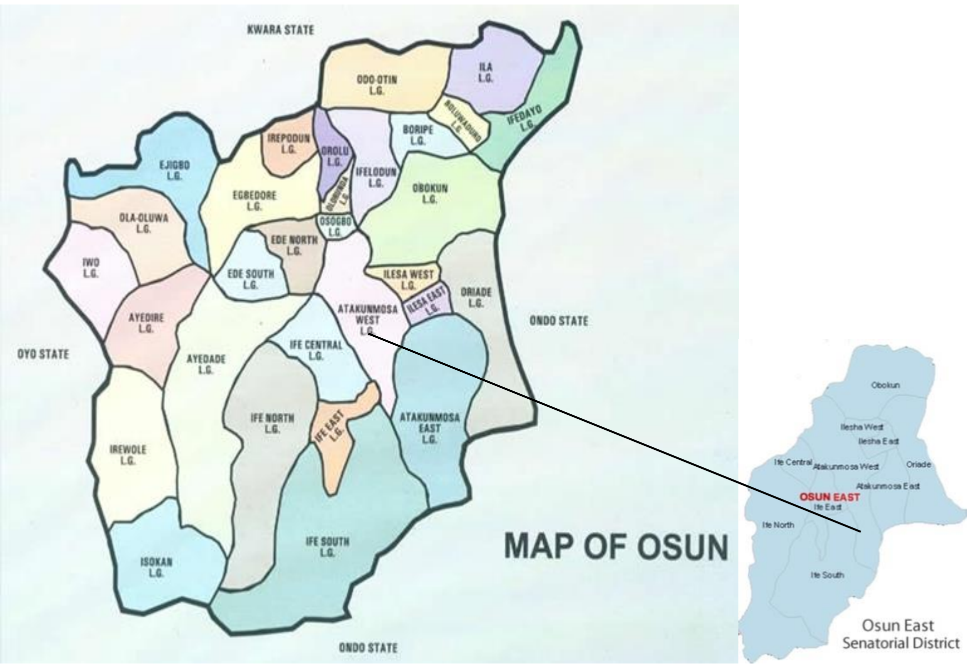

Figure 1. Study location

Description of the Activities at Itagunmodi, Atakunmosa Local Government Area of Osun State, Nigeria

Mining in simple terms is the removal of solid valuables from the earth for economic emancipation; such valuables are known as minerals. They are naturally endowed inorganic materials found in the earth for the benefit of mankind. Such natural substances which include, gold, tin, salt, coal, clay, diamond, iron ore, precious stones of varying types are expensive substance deposited in the earth to make life abundant for man. Exploration of valuable mineral materials from the soil are categorized into surface mining and underground mining which are extracted from deep in the soil. The surface mining is easier to do in terms of funding, time and technological support but the mother deposit is usually located only deeply underground. The surface mining is the most unorganized as the identity of miners are not known, they are mostly itinerants.

Subsequently, within the vegetation area known as Ilu Aaye, lies the procedures for the extraction of Gold from the soil. Plates 1, 2, and 3 explain the procedure; after digging the ground, not just the surface, dig deep ranging from 6 feet and more. In some cases, the pit could go as far as having a tunnel all in search for Gold (Arehart, G. B., 1996). The inner soil been dogged, are fetched with bowls or shovels and are placed on a constructed rail. This rail is made of two long irons supported by log of wood. The rails are made to be in a tilted position, about 90-degrees with the ground. A cut section of rugs are placed on the rail. The slanting position of the rail is to allow easy flow of water with the soil that will accompany it.

Afterwards, water is poured on the soil placed on the rail, and due to the slanting position of the rail, the soil is washed away with its content. Therefore, if there is Gold in any of the soil that is been washed, the Gold will settle or trapped on the rug. Plate 4 shows a sample of extracted pieces of Gold from the rug.

Impact of Mining on Itagunmodi Communities

If the outside world is scrambling for a share of this free-for-all fortune, it is expected that the people whose good fortune it is to be the natives (son-of-the-soil) of the community should be more visceral in the gold rush. However, the reverse is the case in Itagunmodi. The community's apathy to gold is writ large, not only in the pervading lukewarm attitude, but also in the town's dwindling population, occasioned by its younger populace migrating to nearby urban areas such as Ilesha and Ile-Ife.

Plate 1: Showing the rail used for extracting form mud

Plate 2: Showing a dug pit

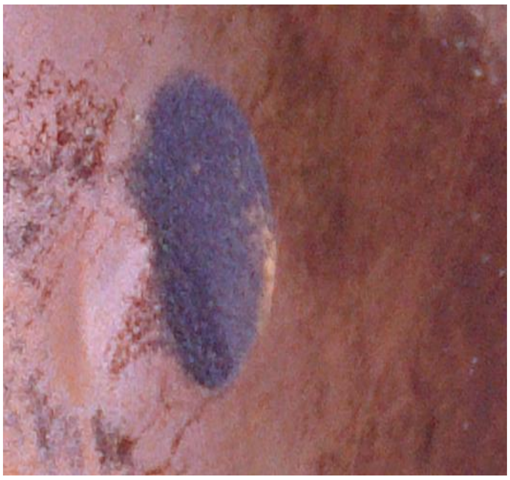

Plate 3: A devastating effect of the vegetation Plate 4: Showing little piece of gold extracted

Mineral deposits are supposed to be a source of joy and wealth to the communities where they are deposited and not a curse (Bello, A. A., 1997). But the reverse has been the case in many communities like Itagunmodi. Deforestation on the guise of anything, can be detrimental to the survival of living things around it, and its alteration has led to economic and environmental disasters (NEST, 1991)

Destruction of Farms, Erosion, Exploitation in Osun

Osun State communities have had their portion of the sour pill as experienced by Itagunmodi community in the Atakumosa West local government area, where gold is largely deposited. The communities suffered inhuman treatment from illegal miners who, apart from destroying their farmland with impunity, also experienced environmental degradation. Itagunmodi community revealed the scrapping of top soil that is good for farming, destruction of farm land, cutting down of economic trees such as cocoa trees, kolanut trees, citrus trees among others, encouragement of gully erosion, and construction of illegal underground mines that is causing environmental hazard by illegal miners. Besides these, the community were cheated and exploited because they were ignorant of the economic value of the mineral deposit and by the time they realized its value, much damage had been done.

It was gathered that following the report of the illegal exploration at the office of the department of mineral resources of the Ministry of Commerce and Industry by the communities concerned at Osogbo, the state capital, further mining activities were banned by the state government. Contrary to Joshua Dada and Obinna Ogbonnaya (2013) who reported as at then, no gold mining activity is going on at either Igun and Itagunmodi or any part of the state, but in December, 2015, there was evidence showing that there still exist these illegal mining activities going on.

Ways to Manage Forest Resources

Evidently, there is the need for the management of the forest resources and also to ensure its sustainability for the benefit of all. Okonkwo *et al.* (2002), outlined the strategies for successful monitoring and management of natural resource which will depend on:

- The level of commitment by the people living in that area

- The political willingness of the policy makers in ensuring the passage of laws that will sustain the forest
- Availability of resources to ensure total cooperation with the stakeholders.

CONCLUSION AND RECOMMENDATION

Generally speaking, at the itagunmodi Gold mining site, lots of effort are involved in the mining of this gold; the stress and energy involved, and the illegal way this mining is been done. Effort should be made, so as to make the mining of gold legal in the area. As this would secure the environment and vegetation of that area, because, what is been done by illegal miners destroys the vegetation, farmland and the lively hood of the people of Itagunmodi.

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Assessment of Locust beans Waste Water for Irrigation Purpose

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ABSTRACT

The best way to control indiscriminate disposal of waste water is to harness its full potential. However, the menace caused by the indiscriminate disposal of locust bean waste water is associated with land and water degradation as well as health risk that may constitute to human being, through inhaling of its unpleasant odour from the environment. This demand for thorough assessment of locust bean waste water for irrigation purposes. The fermented waste water sample of locust bean was collected from processing center and were taken to the laboratory for comprehensive analysis on chemical parameters such as salinity (Electrical conductivity), cations and Anions (Ca^{++}, Mg^{++}, K^{+}, Na^{+}, CT^{-}, $So4^{-}$, $Co3^{-}$, $No3^{-}$ and HCo_3). However, the results obtained from the analysis were compared with FAO standard and it was discovered that the pH value obtained in this study was 3.5±0.0764, which was found to be lesser than 6.5-8.4 recommended by FAO being the waste water, this increase the risk of mobilized toxic metal that can be absorbed by human. In conclusion, having verified the salinity level in terms of Electrical Conductivity (ECW) of 0.002ds/m value which falls within the standard range of threshold 0-3ds/m. Locust bean waste water could be used as irrigation water by local farmers.

Keyword; Locust Beans; Waste Water; Electrical conductivity; Irrigation.

1.0 INTRODUCTION

African locust bean is botanically known as *Parkia biglobosa* and usually called “iru” in yoruba. It is a perennial tree belongs to family of parkia (Anyanwu *et al.*, 2013). The tree is not usually cultivated but can be in population of two or more in the savannah region of West African (Hopkins, 2008). Research revealed that locust bean helps to promote sight and drives away hypertension and conditions like stroke and diabetes. Fermented African locust bean seed, “irú”, provides dietary fiber, energy, minerals and vitamins, and also improves sensory properties of food, including the organoleptic characteristics (appearance, aroma and flavor (Kolapo, 2007)

However, in recent decades, there have been growing concerns on the harmful effects created by locust bean waste water to the environment in which aquatic habitat are of no exception (Anyanwu *et al.*, 2013). Also, it may also pose human health challenges directly through inhaling of its unpleasant odour from the environment and depletion of oxygen. Consequently, this menace could be traced to indiscriminate disposal of most of agricultural produces in most part of developing countries, especially in Nigeria.

In order to control this ugly situation, it has become imperative to harness the potential of this fermented locust bean effluent water by assessing its suitability for production of crops without applying chemical fertilizers. Many researchers have not really paid much attention to this area. It is hypnotized that the effluent waters will be suitable for crop production when it's been firstly assessed in terms of its quality for irrigation without the use of chemical fertilizers. Therefore, this research work toward assessing locust bean waste water for irrigation purpose. This will help in hygiene of the environment as well as to prevent other associated menace cause by locust bean waste water.

2.0 METHODOLOGY

2.1 Description of the study area

The study area, Igboora, is the headquarters of Ibarapa Central Local Government Area of Oyo State, Southwest Nigeria. Igboora is located on longitude 7° 26' 1.79"N, latitude 3°17' 16.37' E. Igboora is approximately 66 km North-northwest of Ibadan, the Oyo State capital and about 32 km North of Abeokuta, the capital of Ogun State. Igboora share boundary with Ogun State to the South and West, Ibarapa North Local Government Area to the North-West, Iselin Local Government Area to the North-East and Ibarapa East Local Government to the East. (Adejumo and Adeyemi, 2021).

2.2 Sample Collection

Four days fermented locust bean waste water samples were collected from three different locations of locust bean processing Centre that uses the same processing techniques in Igboora, Ibarapa Central Local Government into each plastic bottle of 1litre and were taken to the laboratory for comprehensive chemical component analysis.

2.3 Laboratory Analysis

Comprehensive chemical analysis was carried out on the three different samples which were labelled sample A, sample B and sample C on locust bean waste water. The result obtained was compared with FAO standard for irrigation water.

3.0 RESULTS AND DISCUSSION

Table 1 Chemical analysis of locust bean waste water collected from three different locations

Water parameter	Symbol	Unit	Samples			Mean	SE Mean	St Dev	FAO Standard
			A	B	C				

Salinity									
Electrical Conductivity	ECW	Ds/m	0.002	0.002	0.002	0.002	0.000	0.000	0-3
Total Dissolved Solid	TDS	Mg/l	9.860	9.960	9.935	9.9183	0.0300	0.0520	0-2000
Cation and Anions									
Calcium	Ca^{++}	Mel/l	11.427	12.714	12.563	12.235	0.406	0.704	0-20
Magnesium	Mg^{++}	Mel/l	15.179	15.680	15.340	15.400	0.148	0.256	0-5
Sodium	Na^{+}	Mel/l	15.425	18.079	15.976	16.493	0.809	1.401	0-40
Chloride	CL^{-}	Mel/l	2.397	3.195	2.874	2.822	0.232	0.402	0-30
Sulphate	SO_4^{2-}	Mel/l	0.7525	0.9290	0.9320	0.8712	0.0593	0.1028	0-20
Carbonate	CO_3^{-}	Mel/l	0.000	0.000	0.000	0.000	0.000	0.000	0-0.1
Nitrate	NO_3^{-}	Mel/l	0.364	0.477	0.412	0.4177	0.0327	0.0567	0-10
Potassium	K^{+}	Mel/l	4.578	5.074	5.245	4.966	0.200	0.346	0-2
Miscellaneous Effect									
Bicarbonate	HCO_3	Mel/l	0.0262	0.0360	0.0286	0.03027	0.00295	0.00511	0-10
Ph Value	H		3.60	3.50	3.65	3.5833	0.0441	0.07641	6.0-8.5

The parameters for chemical analysis of irrigation water must focused on chemical components ranging from salinity (Electrical conductivity ECW), and Total dissolved solid (TDS), Cations and Anions (Calcium Ca^{++}), Magnesium (Mg^{++}), Sodium (Na^{+}), Chloride (Cl^{-}), Sulphate (SO_4^{-}), Carbonate (CO_3^{-}), Potassium (K^{+}), Bicarbonate (HCO_3), Nutrient (Nitrate NO_3^{-}) ditto to pH Value.

Salinity

The standard range of salinity ECW and TDS is between 0-3ds/m and 0-2000mg/l respectively while the ECW of the sample tested as presented in Table 1 is 0.002 for ECW and 9.9183±0.052mg/l for TDS. The value obtained falls within the FAO recommended range. This indicated that, locust beans waste water will not have adverse effects on both the growth and yield of plants since it falls within the standard value according to FAO.

Cation and Anions

The test result obtained for calcium (Ca^{++}) is 12.235±0.704mel/l as shown in Table 1 while the normal value range for calcium is 0-20 according to FAO, therefore the value obtained in this study falls within the range. However, this established that locust bean waste water will have positive effects on the root growth of the plant.

The test of the sample in Table 1 revealed that the result of the magnesium (mg^{++}) is 15.400±0.256mel/l, while the normal range according to FAO is 0-5. However, this fall outside the normal. The higher concentration of the magnesium is due to source of the water (waste water).

Sodium (Na^+) has moderate concentration value of 16.493±1.401mel/l while the standard value of sodium according to FAO is ranging between 0-40 mel/l as presented in Table 1. This implies that, the value obtained falls within the normal range. This will not have adverse effects on physical condition and soil structure which usually resulting in the formation of crusts, water reduced soil permeability as well as toxicity to certain types of crops. It will not have negative effect on sensitive crops.

The analysis of the test in Table 1 shows that, the value obtained for chloride is 2.822±0.402mel/l while the recommended range of value according FAO is 0-30mel/l. The result obtained falls within the normal range. However, this indicated that, the ability of plants to take up water which is usually leads to reduction in the growth rate known as osmotic effect and crop sensitivity will not be affected if locust beans waste is used as irrigation water.

The result of chemical analysis on the samples as shown in Table 1, indicated that sulphate (SO_4^{2-}) have a value of 0.8712±0.1028mel/l while the normal range value is from 0-20. However, this value falls within the normal range and this will not have negative effects on the growth and yield of the plant.

The analysis of the sample in Table 1 shows that the sample contained lower carbonate concentration of 0.0000mel/l while the normal value for carbonate according to FAO is 0-10mel/l. This implies it will not have negative effects on pH which is usually making nutrients less available to the plants

Nutrient

The test of the samples in Table 1 also shows the higher concentration content of nitrate (nutrient) with a value of 0.4177±0.0567mel/l while the standard value range according FAO is from 0-10mel/l. The result obtained in this study falls within the normal range. This clearly shows that the sample is rich in nutrient and it may not affect susceptible crop

Potassium (K^+) have higher concentration content of 4.966±0.346mel/l while the standard value range for potassium according to FAO is 0-2mel/l as shown in Table 1. However, this value falls outside the recommended range of 0.02mel/l. by FAO. The high value obtained in this study may have negative effect on infiltration, water availability and plant growth.

Miscellaneous Effect

The result of sample in Table 1 revealed that Bicarbonate HNO_3 value of 0.0303±0.0051mel/l was obtained which indicated a lower concentration of the normal value range according to FAO is 0-10mel/l. However, this value falls within the range of normal value. This lower concentration of bicarbonate will not have effect on calcium. And it will not also have effects on physiological effect on roots which usually reducing nutrients absorption.

The pH normal value range according FAO for irrigation water is from 6.5 to 8.4, which the results of pH value of obtained in the study as presented in Table 1 is 3.5833±0.0764. The value of the samples tested fall outside the standard range of value. The adverse or negative effect of this value is that, it may cause a nutritional imbalance or may contain toxic ion since pH Value test is a good indication of quality water. The reason behind this value is due to the source of this water sample (waste water).

4.0 CONCLUSION

Locust bean waste water was collected locust processing site in Igbo Ora, Oyo State. The chemical analysis test was carried out at the laboratory. The test was carried out on chemical parameters such as salinity (ECW), Cations and Anions (Ca^{++}, Mg^{++}, K^{+}, Na^{+}, Cl^{-}, SO_4^{-}, CO_3^{-}, NO_3^{-} and HCO3).

However, having compared the results obtained from the samples with the FAO standard, It was observed that pH Value of 3.5 is lesser to the normal range 6.5 to 8.4, magnesium (mg^{++}), and potassium (K^{+}) greater than normal range while, sodium, chloride, sulphate, carbonate, bicarbonate, nitrate and calcium falls within the normal range. Therefore, it can be concluded that the locust bean waste water is very rich in nutrients and could be useful for irrigation by local farmers.

Also, the locust bean waste water could be used precisely to grow vegetable having verified its salinity level in terms of Electrical conductivity (ECW) of 0.02 value which fall within the standard thresh hold. This could be rated as moderately sensitive (MS). However, further evaluation needs to be carried out on magnesium [mg++] potassium (K+) and pH value of the samples. In order to ascertain its suitability for vegetable productions without the use of chemical fertilizer [NPK].

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Influence of anthropogenic co_2 concentration on the recent rainfall extremes along the Lagos coast

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ABSTRACT

Climate variabilities has been a subject of concern lately in the international community because of its devastating impacts on man and the ecosystem. According to Intergovernmental Panel on Climate Change (IPCC 2018), emission of anthropogenic co_2 into the atmosphere is the main driver of climate change. This study examines influence of anthropogenic co_2 concentration on the recent rainfall extremes along the Lagos coast. Results showed that as a result of the anthropogenic co_2 concentration in the atmosphere, the amount of rain is decreasing in the recent time but the number of extreme cases is increasing.

INTRODUCTION

Naturally, the sun's radiation heats both the ocean and the land surface, leading to water evaporation, which then moves around with winds in the atmosphere, condenses to form clouds, and falls back to the Earth's surface as rain or snow, with the flow to oceans via rivers completing the global hydrological (water) cycle. Precipitation varies from year to year and over decades, and changes in amount, intensity, frequency, and type (e.g., snow vs. rain) affect the environment and society. Steady moderate rains soak into the soil and benefit plants, while the same amounts of rainfall in a short period of time may cause local flooding and runoff, leaving soils much drier at the end of the day. Climate change alters the natural flowing of the hydrological circle, thus effectuating catastrophic events that will lead to an increase in the climatic extremes in terms of frequency and intensity of rainfall. Climatic extremes could contribute negatively (water scarcity or drought) or positively (flood) to rainfall. Anthropogenic activities such as burning of fossils are one of the major contributors to the climate problem (Oreskes 2004). Climate change and food security are related because climate change affects the climatic conditions responsible for optimum food production. Evidence is building that human-induced climate change (global warming), is changing precipitation and the hydrological cycle, especially the extremes as the atmospheric level of carbon dioxide has been greatly impacted. Lagos state economic hub of Nigeria and West Africa with five ports, houses about 65 % of the country's industrial establishments and 60 % of Nigeria's non-oil economy (Adelekan, 2010). The state accounts for about 32% of the overall national Gross Domestic Product of Nigeria (GDP) with an average internally generated revenue (IGR) between $32 million and $52 million (Filani, 2012). Furthermore, Nigeria's economy is closely tied to oil and gas as profits from petroleum exports currently account for 86% of Nigeria total income. These activities have contributed greatly to carbon emissions. Several studies have shown that carbon dioxide could impact the atmosphere through fast adjustment of surface temperature (Ekwurzel et al., 2017) possible changes in monsoon precipitation with the increase in carbon dioxide concentration have also been considered by several researchers (Loo *et. al.,* 2015, Sohn *et. al*., 2019). Rainstorm events which are known to be detrimental to agricultural production is evident in Lagos state lately with little knowledge on the major causes. This study examines the recent rainstorm events under the rising atmospheric co_2 concentration occasioned by anthropogenic activities in Lagos megacity.

MATERIALS AND METHODS

The climatological rainfall data used for the present study were acquired from Nigeria Meteorological Agency (NIMET) spanning from 1986 to 2020 (long term), and Nigerian Institute for Oceanography and Marine Research (NIOMR) meteorological station (Badore station) for the year 2021 (short term). Atmospheric co_2 concentration data were obtained from National Oceanic and Atmospheric Administration (NOAA) spanning from 2009-2021. Qualitative and quantitative quality control was performed on the data to meet the objective of the study. Data analysis was performed using SciPy software. Rainfall amount was classified according to the American Meteorological Society (AMS) as thus:

- Rain day: The amount of rain ≥ 0 mm
- Rainstorm: The amount of rain (≥ 10 mm, ≤ 50 mm)
- Violent Rain: The amount of rain ≥ 50 mm

RESULTS AND DISCUSSIONS

Climate is an important factor affecting agricultural productivity. Agriculture and food production depend fundamentally on climatic factors. Climate change is already affecting the earth's temperature, precipitation, and hydrological cycle. Continued changes in the frequency and intensity of precipitation, heat waves, and other extreme events are affecting agricultural production. Climatic changes due to anthropogenic factors have been identified as the main driver of these changes (Ekwurzel et al., 2017), championed by anthropogenic atmospheric co_2 emissions. Analysis of the monthly mean mass fraction of carbon in the air along the Lagos coast from 2009 to 2021 as shown in figure (1) shows that the anthropogenic co_2 is increasing with a slight drop in 2020. The slight drop in co_2 emission in 2020 could be linked to Covid-19 activities where the country was on total lockdown for nearly half of the year which consequently halted industrial activities. This exponential increase in co_2 emissions has greatly impacted the rain patterns and consequently increases rainstorm events in Lagos. Figure (2) show that there is no significant trend in the rainfall pattern throughout the study period but the number of extreme rainfall events is increasing lately. For instance, in 1985, the number of rain days was 104, and the number of rainstorm events was 40 which constitute about 38.48% of the total rainfalls throughout the year. The total amount of rainfall and yearly maximum recorded in the year was 1052.9 mm and 55 mm respectively with 1 violent drop of rainfall constituting about 0.96% as depicted in figure (3). On the other hand, the number of rainy days in 2018 was 80 and the number of rainstorm events recorded was 42, constituting about 52.5% of the total rainfall. The total amount of rainfall was 1339.8 mm, and the yearly maximum was 119.5 mm with 6 violent drops of rain constituting about 7.5% of the total rainfall. Similarly, the amount of rainfall is decreasing lately as shown in figure (4), but the number of rainstorms keeps increasing. For instance, the year 2021 has 44 rainstorm events and 4 violent drops of rain with a total rainfall amount of 1411.11 mm throughout the year as depicted in figure (5). Activities of rainstorm events could result in severe flooding events, consequently leading to soil degradation, damage to crops, increasing flood risk, and also may reduce fish density and biomass, influencing community composition (Milner et al., 2012).

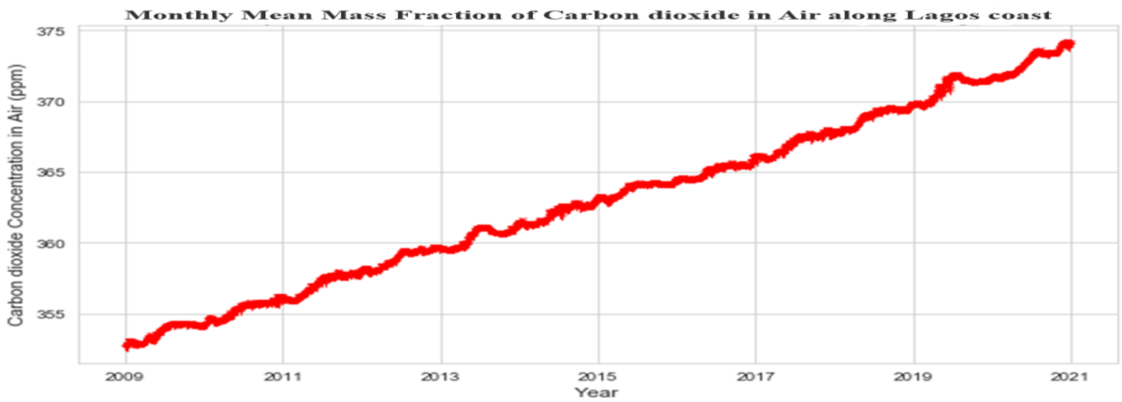

Figure 3.1. Monthly mean mass fraction of carbon dioxide in the air along the Lagos coast

Figure 3.2. Climatological Rainfall pattern along the Lagos coast (1985 and 2018)

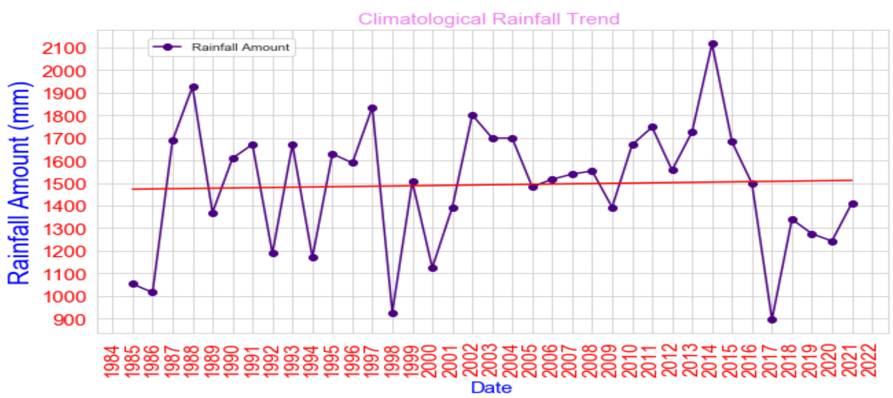

Figure 2. Climatological Rainfall trend (historical and recent) along the Lagos coast

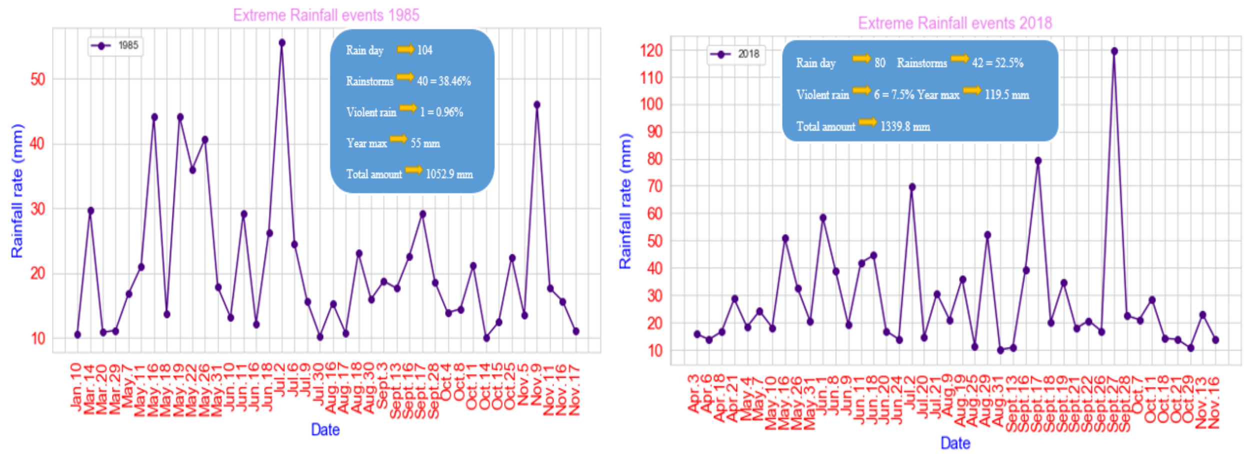

Figure 3. Diurnal Rainfall pattern along the Lagos coast (February – July 2021)

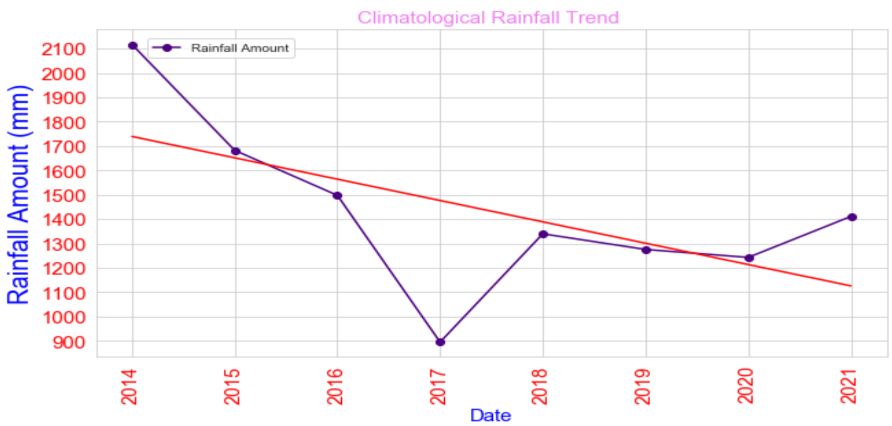

Figure 4. Climatological Rainfall trend (historical and recent) along the Lagos coast

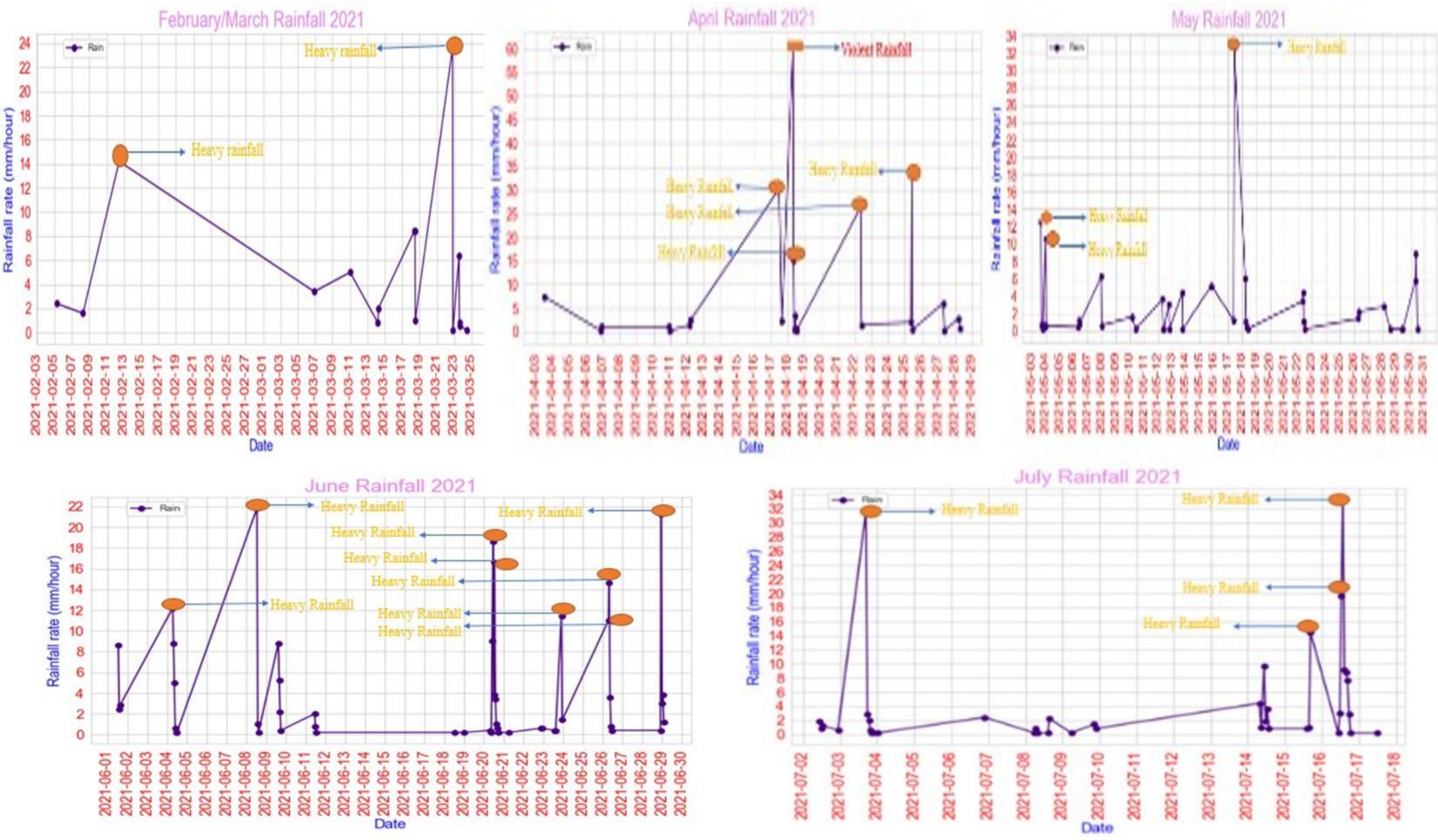

Figure 5. Climatological Rainfall trend (historical and recent) along the Lagos coast

CONCLUSIONS

Anthropogenic activities most especially emission of co_2 , which is the major greenhouse gas into the atmosphere is the major cause of climate change. The present study has examined the influence of anthropogenic co_2 concentration in the atmosphere on the recent rainfall extremes along the Lagos coast using NOAA atmospheric co_2 concentration and NIMET – NIOMR rainfall data with a well-structured analytical method. Results show that the amount of rain is decreasing lately but the number of extreme cases is increasing. This is attributed to the co_2 concentration in the atmosphere.

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An overview of some modern breeding techniques in plant biotechnology

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ABSTRACT

Plant biotechnology is the use of tissue culture and genetic engineering techniques to modify and produce new plants that exhibit desirable characteristics. Plant biotechnology provides plant scientists or breeders an opportunity to achieve certain goals that would otherwise be impossible through conventional plant breeding approaches. Plant biotechnological techniques have evolved rapidly in recent years from tissue culture to more advanced and sophisticated techniques like genomics-assisted breeding, next-generation sequencing methods, molecular breeding, gene editing, genetic engineering etc. These recent advancements have revolutionized plant breeding and crop improvement resulting in the creation of high-yielding, better adapted crop varieties that are resilient to climate change, pest and diseases. In the face of food insecurity, exacerbated by climate change and other natural disasters, plant biotechnology tools or techniques can be deployed as a strategy to combat these exigencies. Hence, this paper gives an overview of the advances in plant biotechnology that has aided the quantum leap in crop improvement in recent years, with profound implication for developing countries like Nigeria where food production is largely at the subsistence level.

Keywords: Plant biotechnology, food security, climate change, crop breeding, crop improvement.

INTRODUCTION

Fulfilling the goal of attaining food security for the present and future generations is of prime importance. Climatic related challenges like rapid changes in temperatures, alterations of rainfall patterns, floods or drought conditions, and outbreaks of pests and diseases extremes have caused a range of negative impacts on plants (Munaweera *et al*., 2022). As a result, plant scientists and breeders are under increasing pressure to develop smart crops with superior genes, that are highly resistant to disease and pest, and adaptable to a wide range of climatic variability, in a bid to tackle food and nutritional insecurity. Conventional plant breeding approaches, which have played a key role in food security until now seem to be insufficient. Several years ago, plant biotechnology comprised only a few applications of tissue culture, recombinant DNA technology and monoclonal antibodies. Today, transformation, and marker-aided selection and breeding are just a few of the examples of the applications of biotechnology in crop improvement (Izquierdo, 2000). The development of biotechnological approaches such as genetic engineering, genome editing, RNA-mediated gene silencing, armored with next-generation sequencing, and genome mapping have paved the way for precise and faster genetic modifications of plants.(Munaweera *et al*., 2022).

Some Modern Breeding Techniques:
Plant Tissue Culture

Plant tissue culture is the growing and multiplication of living plant cells, tissues, and organs in a liquid artificial media (in vitro), under aseptic and controlled environment conditions. Tissue culture techniques allow thousands of new plants to be obtained from a single plant, making the technology attractive to rapidly multiply new cultivars. Tissue culture has immensely contributed to the growth and development of many crops and it helps breeders save time during the breeding process such as helping with propagation of difficult to grow plants. Tissue culture has been used in the production and development of quality and improved cultivars (Lalitha *et al.*, 2014). It is useful for germplasm conservation, production of Genetically Modified Organisms (GMO), cryopreservation, and also helps industries with production of secondary metabolites (Prakash *et al.*, 2004). Cell regeneration by tissue culture is made possible due to the ability of a plant cell to form a multicellular organism, which is commonly called Tortipotency (Lima *et al.*, 2012). Along with the totipotent potential of plant cell, the capacity of cells to alter their metabolism, growth and development is also equally important and crucial to regenerate the entire plant (Thorpe, 2007). Regeneration of new species and improved culture techniques opened new horizons for practical breeding in number of crops (Tom *et al*., 2013). The tissue culture process can be divided into four steps or stages: explanting, multiplication, organogenesis and acclimatization. While tissue culture is a viable method of increasing the numbers of a single clone, compared with conventional asexual propagation methods, the success rate depends on the skill of the technician practicing it. Contamination is also a constant problem and leads to disappointing results. Also, each plant species has its own special growing requirements, although protocols have been established for many important species, there are many more species whose protocols are yet to be determined.

Genetic Modification And Engineering Applications

Genetically modified organisms (GMOs) are the ones in which the genomic material, DNA (deoxyribonucleic acid), has been transferred from a bacterium or a plant, or even an animal, into a different plant species to obtain the desired and improved quality. Genetic engineering modifies the genetic material of crops to display specific traits (Fernandez-Cornejo and Caswell, 2006). This technology is often recognized as “recombinant DNA technology” or “genetic engineering” and the resultant organism is said to be “genetically engineered,” “genetically modified,” or “transgenic”. Genetic modification entails series of laboratory techniques for cloning genes, splicing DNA segments together, and inserting genes into cells. Most genetically engineered crops are transformed to be either herbicide tolerant, to destroy weeds without damaging crops, or insect resistant, to shield plants from harmful pests (Khan and Hakeem, 2015). According to USDA standards for organic agriculture, seeds or other substances derived through GM technology are not allowed in organic production (Byrne, 2014). According to (Khan and Hakeem, 2015), several food crops have been modified to increase production and durability; the examples are cotton, sugarcane, tomatoes, soybean, Hawaiian papaya, potatoes, rice, rapeseed, sugar beet, field corn, and sweet corn.

Genome Editing

Genome editing is a revolutionary technology for the advancement of plant science and crop breeding (Chen *et al*., 2019). Genome editing enables modification of plants' owned genes, without insertion of external genes, as with GM crops. Genome-edited varieties possess no foreign DNA and are indistinguishable from crops developed through conventional plant-breeding methods, or using naturally occurring mutations (Hua *et al*., 2018). Gene editing has a broad spectrum of applications, from knocking out a gene to quickly generating a recessive but desired trait, such as fragrance and early maturity (Shan *et a*l., 2015), to generating new alleles by nucleotide substitution to create a novel trait (Hua *et al*., 2018). To date, several base and prime editor tools are developed based on CRISPR/Cas (clustered regularly interspaced short palindromic repeats -associated system), in order to perform more precise editing (Zhu *et al*., 2020). These editing tools are helping breeders modify target genes to the desired sequence for improving crops yield and quality, increase biotic/abiotic stress tolerance and herbicide resistance in crops (Chen *et al*., 2019). Genome editing is therefore considered the next generation breeding strategy.

Proteomics

Proteomics can be defined as the systematic analysis of proteome, the protein complement of genome (Pandey and Mann, 2000; Patterson and Aebersold, 2003; Phizicky *et al*., 2003). This technology allows the global analysis of gene products in various tissues and physiological states of cells. With the completion of genome sequencing projects and the development of analytical methods for protein characterization, proteomics has become a major field of functional genomics. The initial objective of proteomics was the large-scale identification of all protein species in a cell or tissue. The knowledge of key proteins that play crucial roles in the proper growth and development of a plant are critical to propel the biotechnological improvement of crop plants (Eldakak *et al*., 2013). The applications are currently diversified to analyze various functional aspects of proteins such as post-translational modifications, protein-protein interactions, activities and structures. Eldakak *et al.* (2013) reported the use of proteomics for genetic improvements in food and biofuel crops, including food quality, safety, and nutritional values, tolerance to abiotic and biotic stresses, manufacturing plant-based vaccines and proteomics-based fungicides. Apart from these, proteomics is also being used for several other crop improvement programs such as, pre- and post-harvest losses, and crop quality characteristics.

Molecular Breeding and Marker Assisted Selection And Molecular Breeding

Molecular breeding (MB) may be defined in a broad-sense as the use of genetic manipulation performed at DNA molecular levels to improve characters of interest in plants and animals, including genetic engineering or gene manipulation, molecular marker-assisted selection, genomic selection, etc. More often, however, molecular breeding implies molecular marker-assisted breeding (MAB) and is defined as the application of molecular biotechnology, specifically molecular markers, in combination with linkage maps and genomics, to alter and improve plant or animal traits on the basis of genotypic assays (Collard and Mackill, 2008). This term is used to describe several modern breeding strategies, including marker-assisted selection (MAS), marker-assisted backcrossing (MABC), marker-assisted recurrent selection (MARS), and genome-wide selection (GWS) or genomic selection (GS) (Ribaut *et al*., 2010). Marker-assisted selection (MAS), which is the employment of DNA marker in plant breeding programs, has extensively been used to select desired genes/quantitative trait loci (QTLs) in the development of a comparatively superior breeding line (Collard and Mackill, 2008).

Plant Metabolomics

After the establishment of technologies for high-throughput DNA sequencing (genomics), gene expression analysis (transcriptomics), and protein analysis (proteomics), the remaining functional genomics challenge is that of metabolomics. Metabolomics is the term coined for essentially comprehensive, non-biased, high-throughput analyses of complex metabolite mixtures typical of plant extracts (Hall *et al*., 2002). Plant metabolomics, a branch of metabolomics, is designed to study the overall changes in a large number of metabolites in plant samples and then conduct deep data mining and bioinformation analysis (Xiao *et al*., 2020). This potentially holistic approach to metabolome analysis is driven primarily by recent advances in mass spectrometry (MS) technology and by the goals of functional genomics research. Achieving the broadest overview of metabolic composition is very complex and entails establishing a multifaceted, fully integrated strategy for optimal sample extraction, metabolite separation/detection/identification, automated data gathering/handling/analysis, and ultimately, quantification. Both analytical and computational developments are essential to achieve this goal (Hall *et al*., 2002). Metabolomics information not only will assist in the establishment of a deeper understanding of the complex interactive nature of plant metabolic networks and their responses to environmental and genetic change but also will provide unique insights into the fundamental nature of plant phenotypes in relation to development, physiology, tissue identity, resistance, biodiversity, etc.

CONCLUSION

New technologies, such as plant biotechnology, if properly focused, offer a responsible way to enhance agricultural productivity for now and the future. Genetic modification can be a misleading terminology, in that virtually everything we eat has been modified genetically one way or another, especially through domestication from wild species, and many generations of selection by humans for desirable traits. So, to attain food security status, in the face of climate extremes, pest and diseases, developing countries like Nigeria need to take advantage of the various next generation plant breeding tools.

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Severity of Some Foliar Diseases on Selected Tomato Varieties and Associated Pathogens in a Derived Savannah Agroecology

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ABSTRACT

Tomato leaf diseases can be severe, causing defoliation and eventually killing the plant if not properly managed. Estimating disease severity is crucial for yield loss prediction and disease management. Identification of pathogens enable selection of pathogen-free planting materials that are essential for improved yield and quality. The present study identified the pathogens associated with foliar diseases on four tomato varieties and assessed their severity**.** Four tomato varieties (Tropimech, Tima, Roma VF and Omu-Aran Local) were raised in the nursery and transplanted to Sites A and B on the field. The experimental design was laid in a randomized complete block design with three replicates. Leaves of the tomato plants were observed for foliar disease symptoms. The pathogens associated with the diseases were identified and data were collected on disease severity at 2, 4 and 6 weeks after transplanting (WAT). Data collected were subjected to analysis of variance using SPSS package and means were separated using Duncan multiple range test at 5% probability level. The identified foliar diseases were early blight (*Alternaria solani*), bacterial wilt (*Ralstonia solanacearum*) and curly top (curly top virus). The lowest early blight severity (0.5) was recorded on Omu-Aran Local in Site A. At 4 WAT in Site A, Tima had the highest severity of bacterial wilt (3.5), followed by Tropimech (2.5). Bacterial wilt was the most severe foliar disease encountered in the study area. Roma VF and Omu-Aran local are recommended for planting in areas where bacterial wilt is widespread while Tima is suitable where early blight is prevalent. Findings from this study could be a bedrock for breeding and selection of foliar disease resistant tomato varieties.

Keywords: Tomato, early blight, bacterial wilt, curly top virus, severity

INTRODUCTION

Leaves constitute important organ in plants by virtue of their position as the site of photosynthesis (Kumar *et al*., 2015). Tomato is susceptible to several devastating foliar diseases that affects the crop at various stages of growth (Ramyabharathi *et al*., 2013). Tomato leaf diseases cause irregular growth, discolouration, defoliation and eventually killing the plant if not properly managed (Shijie *et al*; 2017; Ewekeye & Odebode, 2021). Any damage to plant leaf will invariably result in decreased yield, both in quantity and quality (Byjus, 2022).

Correct identification of a plant pathogen is a critical step in disease management (Ashqar *et al*., 2018). The ability to identify pathogens enable the selection of pathogen-free planting materials that are essential for higher yield and quality (Ayo-John & Odedara, 2017). Data on disease assessment is crucial to understanding and estimating yield losses, comparing phenotypes for disease resistance or susceptibility (Bock *et al*., 2021).

Leaf spot disease intensity can be evaluated by measuring disease severity, a criterion essential for classifying varieties into susceptibility groups (Wang *et al*., 2017). There is a paucity of data on disease severity on commonly cultivated tomato varieties, particularly in Nigeria. Therefore, the present study identified the pathogens associated with foliar diseases on four tomato varieties and assessed their severity**.**

Materials and Methods

This research was carried out at the Teaching and Research Farm of Landmark University, Omu-Aran, Kwara State, Nigeria. Omu-Aran is located at latitude of 80.9'N and longitude of 50'61 E, in the derived savannah ecological zone. The experiment was conducted at two locations (Sites A and B). The four varieties of tomato used in this study are Roma VF, Tropimech, Tima and Omu-Aran Local. Seeds of the tomato varieties were raised in polythene bags in the screen house for 3 weeks and later transplanted to the field. A land area of 22m^2 was cleared and partitioned into 12 beds at each site, with each bed measuring 1 m x 1 m. The experiment was laid in a randomized complete block design (RCBD) with 3 replicates. The treatments consisted of the four tomato varieties: Roma Vf, Tima, Tropimech and Omu-Aran Local.

Starting from one week after transplanting, the leaves of the plants were observed for symptoms of foliar diseases. Disease observation was based on macroscopic symptoms and infected leaf samples were collected in brown paper envelopes, labelled accordingly and taken to Nigeria Agricultural Quarantine Service, Ibadan, Nigeria and the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, for pathogen identification.

For early blight disease, severity was assessed on a scale of 0-5 according to Rahmatzai *et al*. (2017), where, 0= No symptom on the leaf, 2= < 10% of leaf surface area infected, 3= 11-25% of foliage of plants covered with symptom, 4= 51-75% area of the plant's leaves, fruits and stems with the symptom, and 5= <75% area of plant part with disease symptom.

The plants were scored for bacterial wilt severity according to Tiwari *et al*. (2012), where, 0= No infection, 1= 1-10%, 2= 11-25%, 3=26-50%, 4= 51-75% and 5= 76-100% infection.

For curly top virus, severity was assessed based on the rating scale of Montazeri *et al*. (2016), where, 1= No visible symptoms, 2= Leaf thickened and veins cleared, 3= 2–3 leaves margins curled, and a mild vein swelling and crumpling, 4= 4–5 leaves margins are curled with minor vein swelling and crumpling, 5= Majority of leaves exhibit mild vein swelling, crumpling, and curling, 6= Most leaves having slight vein swelling, crumpling, and curling, 7= Most leaves having moderate vein swelling and crumpling, as well as severe leaf curling, and 8= Severe stunting, swollen and crumpled veins on most leaves, and curled leaf margins.

Fungal and bacterial isolation were carried out according to Rashid *et al*. (2016). Fungal identifications were based on colony characterization and examination under a compound microscope with a magnification of 40X while bacterial colony was observed on a stereomicroscope.Data collected were subjected to analysis of variance (ANOVA) using the SPSS package, and means were separated using Duncan multiple range (DMRT) at a probability level of 5%.

RESULTS

The foliar diseases identified in this study are early blight, bacterial wilt and curly top virus and the associated pathogens are *Alternaria solani*, *Ralstonia solanacearum* and curly top virus, respectively.

Early blight severity: The severity of early blight on the four tomato varieties is presented in Figure 1. In Site A at 2 WAT, there was no significant (P<0.05) difference in disease severity among the four varieties with Roma Vf having the highest value (1.3) and Omu-Aran local the lowest (0.3). At 4 WAT, Roma Vf had the highest severity (2.5) which was not significantly (P<0.05) different from Tima (1.3) and Tropimech (1.3). The lowest early blight severity (0.5) was recorded on Omu-Aran Local. At 6WAT, the highest disease severity (3.0) was recorded on Roma Vf and was significantly (P<0.05) higher than Tropimech (1.8), Tima (1.5) and Omu-Aran Local (1.5), all of which were not significantly (P<0.05) different.

In Site B at 2 WAT, there was no significant difference (P<0.05) in early blight severity among the four tomato varieties. At 4WAT, the highest disease severity (1.8) was recorded on Roma Vf and was significantly higher than Tropimech (0.8), Tima (0.8) and Omu-Aran Local (0.5), all of which were not significantly (P<0.05) different. AT 6 WAT, the highest disease severity was observed in Roma Vf (3.0) and was significantly (P<0.05) higher than Tropimech (1.3), Omu-Aran Local (1.3) and Tima (1.0).

Bacterial wilt severity: The severity of bacterial wilt on the four tomato varieties is presented in Figure 2. At 2 WAT in Site A, the highest disease severity (2.8) was recorded in Tima and was not significantly (P<0.05) different from Tropimech (2.0). The lowest severity was observed in Omu-Aran Local and Roma Vf, both of which were not significantly (P<0.05) different. At 4 WAT, Tima had the highest severity of bacterial wilt (3.5), followed Tropimech (2.5), both of which were not significantly (P<0.05) different. The lowest disease severity was recorded in Omu-Aran Local (1.3) and Roma Vf (0.5), both of which were not significantly (P<0.05) different. At 6 WAT, Tima had a significantly (P<0.05) higher severity (4.8) than the other varieties. There was no significant difference in bacterial wilt severity among Tropimech (2.8), Omu-Aran Local (2.5) and Roma Vf (2.0).

In Site B at 2 WAT, there was no significant (P<0.05) difference in disease severity among the four tomato varieties. At 4 WAT, Tima had a significantly (P<0.05) higher severity (3.8) than the other varieties. There was no significant difference in bacterial wilt severity among Tropimech (1.8), Omu-Aran Local (1.5) and Roma Vf (0.8). At 6 WAT, Tima had the highest severity (5.0), followed by Tropimech (3.3), both of which were not significantly (P<0.05) different. Omu-Aran Local (2.3) and Roma Vf (2.0) had the lowest severity of bacterial wilt, both of which were not significantly (P<0.05) different.

Curly top virus severity: The severity of curly top virus is presented in Figure 3 below. There was no significant difference (P<0.05) in disease severity among all the tomato varieties at 2, 4, and 6 WAT in both Sites A and B.

DISCUSSION

Findings from this study showed that the four tomato varieties (Roma Vf, Tima, Tropimech and Omu-Aran Local) are susceptible to foliar diseases. However, the varieties varied in their degree of susceptibility to these diseases. Roma Vf had the highest severity of early blight, Tima had the highest severity of bacterial wilt while Omu-Aran Local had the highest severity of curly top virus. Variations in pedigree of cultivars, varieties, genotypes or accessions could have influence on resistance or susceptibility to pathogens. This corroborates the findings of Mtui *et al*. (2015) that reported varying reactions of different tomato varieties to infection by pathogens. Adhikari *et al*. (2017) reported that majority of cultivated tomato varieties are susceptible to early blight whereas a few are resistant. This demonstrates varietal differences to early blight pathogen. Roma Vf was moderately susceptible to early blight in accordance with the classification table of Rahmatzai *et al*. (2017).

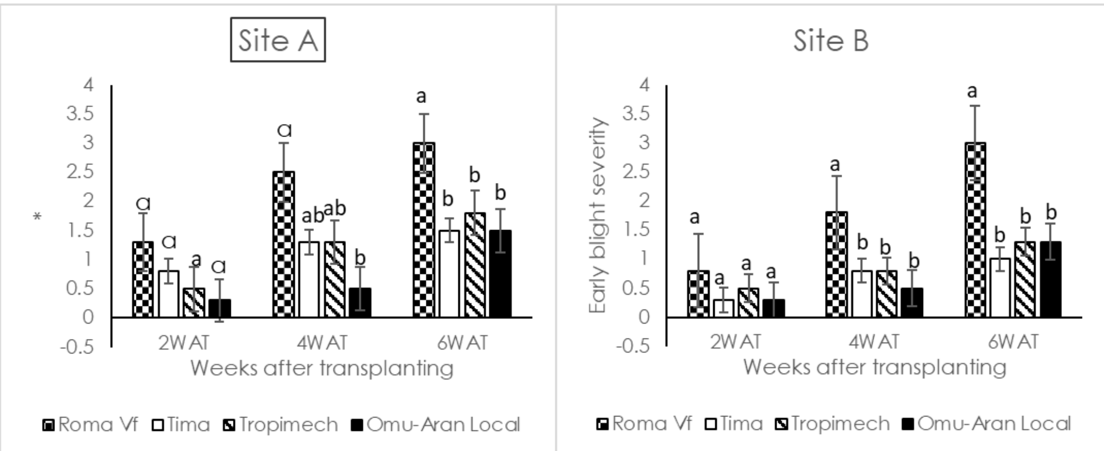
The severity of bacterial wilt disease increased because *R. solanacearum* is a soil-borne pathogen and the regular watering during the growing season might have favoured disease development and symptom expression. Curly top virus severity on the four tomato varieties were low at the two experimental locations. This could be attributed to the fact that curly top virus disease is transmitted by beet leafhoppers insect vector and plants in the Amaranthaceae family are the preferred hosts (Koike & Gilbertson, 2010), as opposed to Solanaceae to which tomato belongs.

The foliar diseases observed in this study are early blight, bacterial wilt and curly top virus and the pathogens attributable are *Alternaria solani*, *Ralstonia solanacearum* and curly top virus, respectively. A similar study conducted by Amuji et al (2012) identified *Fusarium* wilt caused by *Fusarium oxysporum* and soft rot incited by *Rhizopus stolonifera* as the endemic pathogens limiting tomato production in Nsukka, South-eastern Nigeria. Findings from Ewekeye & Odebode (2021) identified leaf spots, chlorosis, and wilting as symptoms of foliar diseases of tomato in Ogun State, Nigeria. Previous research carried out by Opoku *et al*. (2021) also documented early blight on tomato plants in Ghana.

The severity of these foliar diseases increased with tomato growth stages among the varieties evaluated. This observation supports previous research that reported a positive correlation between early blight disease and tomato plant age (Mailem & Singh, 2018). Similar findings were observed by Yerasu *et al*. (2019) who reported varying disease expression in seedlings and older plants.

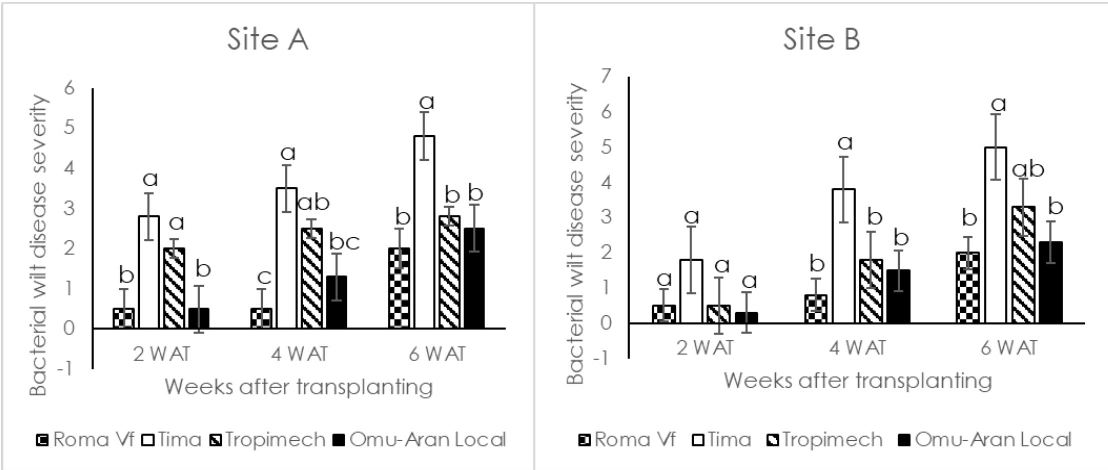
CONCLUSION

Early blight (*Alternaria solani*), bacterial wilt (*Ralstonia solanacearum*) and curly top (curly top virus) were the identified foliar diseases in the study location. Bacterial wilt was however, the most severe, causing considerable damage to the foliage. Roma Vf and Omu-Aran Local are recommended for planting in areas where bacterial wilt is prevalent while Tima is suitable where early blight epidemic occurs. Roma Vf and Tima are recommended for planting in areas with outbreak of curly top virus disease. Findings from this could be a bedrock for breeding and selection of foliar disease resistant tomato varieties.



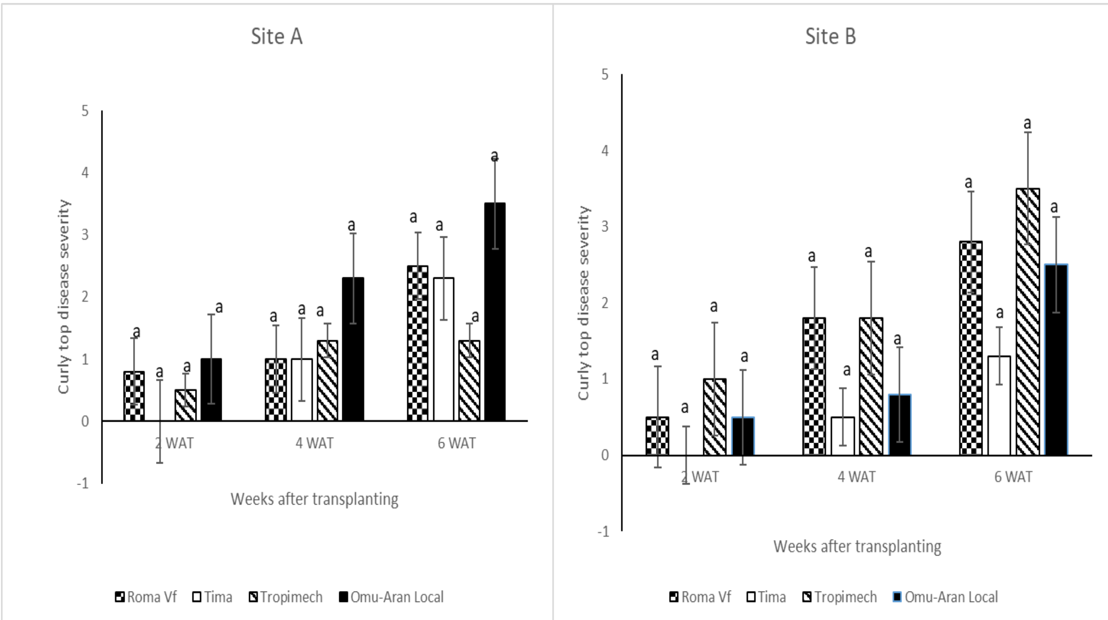
Bars marked with different letters shows means are significantly different at 0.05 level of probability using DMRT. Vertical bars show standard error

Figure 1: Early Blight Severity at Sites A and B



Bars marked with different letters shows means are significantly different at 0.05 level of probability using DMRT. Vertical bars show standard error

Figure 2: Bacterial wilt Severity at Sites A and B



Bars marked with different letters shows means are significantly different at 0.05 level of probability using DMRT. Vertical bars show standard error

Figure 3: Curly top virus severity at Sites A and B

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Micronutrient Variability in Soils of Northern Kaduna, Northern Nigeria

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ABSTRACT

The research was conducted at the northern Kaduna selected arable soils, and intended to study the distribution of micronutrient on these soils. The major arable soils used were previously harvested maize, cowpea and rice soils (designated as Locations A, B and C respectively). The soils were delineated, and three profile pits dug in each along the line of transect of about 100 m apart. A total of nine profile pits were dug in the three delineations and samples collected from each pit according to their horizonations. Major micronutrients investigated were Cu, Fe, Zn and Mn. Virtually all micronutrients decreased down the profile in all studied locations with Cu and Zn displaying an irregular trend in all pedons of rice harvested soils in location C. Also, Fe rather increased in pedon 1 of location C as well. Micronutrients were all low to a deficiency level considering their critical limits in the tropical soils. Activities that will conserve organic matter such as accumulation of litter from harvested crops and alternative means of cattle rearing such ranching rather than freelance grazing should be employed, as efforts to replenish micronutrients through fertilization has not yielded the desired results.

Keywords: soil micronutrients, micronutrient variability, nutrients deficiency, critical limits, northern guinea savanna.

1. INTRODUCTION

Micronutrients is highly important in soil health maintenance and crops productivity. They are usually needed in small amount by plants for their growth and in the synthesis of human food which must come from the soil. The breakdown of certain soil micronutrients such as Zn and Fe with organic matter will oftentimes lead to the formation of root dependable types of these nutrients and also stop the formation of indissoluble types such as carbonates and oxides in soils (Schulin *et al.*, 2009). In tropical soils where acidity is high due to high level of leaching, Zn content of soils may be low resulting to low total Zn content or may be relatively high in total Zn, however crop-available quantity is low because of the chemical composition of soil which encourages the formation of poorly soluble Zn complexes (Rengel, 2002). The handiness or availability of soil Zn for utilization by crops may be hindered by pH, cation exchange capacity (CEC) of soil and liquidity of the mineral which is controlled by the exchangeable sites, build-up of complexes with organic matter and formation of precipitates (Baird and Cann, 2005).

Rufus *et al.*, (2012) carried out a study to investigate the total and extractable concentrations and profile distributions of the micronutrients, Cu, Zn, Fe and Mn, in the main agricultural soils in Northern Nigeria, and associated their variations to effects from lithology and other soil properties. Due to scanty information available on the micronutrient concentration and variability in Northern Nigerian soils, this research however investigated the variability of selected micronutrients in soils of Rigachikun, Northern Guinea Savannah, Nigeria.

2. MATERIALS AND METHODS

2.1 Location

The study area is located on the Latitudes 10^o 36' and 10° 60' N and Longitudes 7^{o}25' and 7° 40'E respectively and in the north western Nigeria**.** It has been characterized as a region where the rainfall is unimodal in pattern and between 900 – 1300 mm per annum (Uyovbisere and Lombin 1991). The region also has a wave-like but relatively plain relief, with general elevation from about 450 to 700 m, dominated by mostly sandy soils, which are usually very low in organic matter, may degrade rapidly under conditions of very high rainfall. The region is also known for its high annual average temperature (28-32°C), short wet season and long dry season (6-9 months). Generally, soil moisture and temperature regimes in the area are inferred to be ustic and isohyperthemic respectively. During the rainy season however, mean temperature drops to 25^{o}C – 28^{o}C (June to September) and decreases to less than 20^{o}C in the months between December and February (Gabasawa *et al.,* 2017). Tree cover varies from open woodland to light forest which has been reduced to bare land due to uncontrolled tree felling for fuel as well s farming activities (Carsky *et al.*, 1998) while abundant short grasses (<2 m) are also available (Sowunmi and Akintola, 2010).

2.2 Existing Information on Soil

The soils of the region mostly exhibit the characteristics of dry lands and its moisture movement in the soil may be slowly permeable, while most of its rain water gets lost by run-off (Fitzpatrick, 1980). They could have been created under severe dry condition from wind-stored desert sands that gathered together over a long period of time. Also, some soils in the northern guinea savanna found in states like; Kaduna, Katsina, Kebbi, Sokoto and Zamfara of northern Nigeria have been suggested to be ferruginous tropic soils (D'Hoore, 1965) and characterized as having mostly sandy texture, spreading through large areas of land having very low water-holding capacity and low organic matter, nitrogen and phosphorus content, neutral or moderately acidic in pH and also having a low cation exchange capacity. Large expanse of arable land exists in this region with potential for the production of largely grain crops like maize, sorghum, millet, rice and wheat (Shehu *et al.*, 2015).

2.3 Field Work

Soils were delineated into mapping units using the cropping land use. Depending on the identified soil groups, Pedons was sunk in each of the delineated mapping units. Three profile pits were dug in each cropping land use for maize, rice and cowpea giving a total of nine profile pits. About 1kg samples was collected from the different horizons of each pedon at the different arable crop grown soils for micronutrient and other soil physicochemical properties study. Samples were carefully packaged and labeled and transported to the standard Soil Science laboratory of ABU, Zaria for analysis.

2.4 Laboratory Soil Analysis

Micronutrients such as Mn, Fe, Cd and Zn were extracted using acid of method of 0.1M HCl and read with Atomic Absorption Spectrophotometer (AAS) as outlined by Kalambe (2021)

2.5 Statistical analysis

Coefficient of Variation (CV) was used to estimate the degree of variability existing among soil properties in the study site. Coefficient of variation (C.V.) ranked as follows; Low variation ≤15%, Moderate variation >15≤35%, High variation >35% was used as outlined by Wilding, (1985). Correlation was done using SPSS software package.

3. RESULTS AND DISCUSSION

Copper (Cu) generally decreased down the soil profile in all studied soils and had their highest concentrations in the first two horizons (A and AB) of all soils. The Cu content was highest in location A where maize was recently harvested from. Mean Cu distributions were as follows in the respective locations. Location A; 2.573, 1.646 and 1.025 mg kg^{-1}; Location B; 0.349, 0.443 and 0.953 $mgkg^{-1}$ and Location C; 0.281, 0.323 and 0.116 mg kg^{-1} in the respective pedons of maize, cowpea and rice harvested plots respectively. In the same vain Fe were more concentrated within the surface horizons and the plough layer but decreased significantly down the profile. More Fe were recorded when compared to other micronutrients in the studied soils. Pedons within Location A (maize harvested plot) recorded more iron content compared to others followed by pedons 3 in location C (rice harvested plot) where Fe content was reasonably higher than their counterparts in other pedons. Location B (cowpea harvested plot) had the lowest Fe distribution having less than 60 $mgkg^{-1}$ Fe in all their respective pedons. Mean Fe ranges in the studied locations were; Location A; 121.53, 88.905 and 83.66 mg kg^{-1}; Location B; 59.760, 47.04 and 58.613 mg kg^{-1}; Location C; 66.13, 53.483 and 107.13 mg kg^{-1} in their pedons 1, 2 and 3 respectively (Table 1). Zn does not seem to show a particular trend in their distribution pattern across pedons and locations, while it decreased in some, it increased in others. Zn has the following mean distributions in locations as thus; Location A; 1.95, 0.99 and 0.67 mg kg^{-1}; Location B; 0.214, 0.33 and 0.596 mg kg^{-1}; Location C; 0.671, 0.936 and 1.245 mg kg^{-1} in pedons respectively. Mn decreased down profiles with pedon means as follows; Location A; 34.121, 14.813 and 18.055 mg kg^{-1}; Location B; 18.728, 12.23 and 14.876 mg kg^{-1}; Location C; 11.27, 10.67 and 20.10 mg kg^{-1} respectively.

Table 1: Micronutrients of Studied soils (mg Kg^{-1})

Horizons	Cu	Fe	Zn	Mn	Cu	Fe	Zn	Mn	Cu	Fe	Zn	Mn
	Pedon 1				Pedon 2				Pedon 3			
					Location A. Maize							
A	3.075	235.47	2.970	100.395	2.040	163.86	1.890	42.330	1.515	138.54	1.395	31.665
AB	3.180	98.175	2.160	18.210	1.230	75.750	0.990	11.100	1.035	51.840	0.405	10.650

Bt1	1.980	73.620	1.305	11.250	1.230	37.710	0.600	3.675	0.525	60.600	0.210	11.850
Bt2	2.055	78.855	1.365	6.630	2.085	78.300	0.480	2.145				
Mean	2.573	121.53	1.950	34.121	1.646	88.905	0.990	14.813	1.025	83.660	0.670	18.055
CV	29.22	63.10	40.19	130.2	48.3	59.96	64.47	126.6	67.04	57.05	94.83	65.36
Location B. Cowpea												
A	0.045	96.900	0.390	54.180	0.615	39.405	0.630	19.020	0.195	91.095	0.360	36.120
AB	0.585	53.550	0.150	8.715	0.810	33.135	0.045	8.565	0.345	40.140	0.795	7.410
Bt1	0.300	47.895	0.165	6.120	0.135	57.465	0.030	10.410	0.075	52.545	0.330	6.600
Bt2	0.465	40.695	0.150	5.895	0.210	58.155	0.615	10.905	0.150	50.670	0.900	9.375
Mean	0.349	59.760	0.214	18.728	0.443	47.040	0.330	12.225	0.953	58.613	0.596	14.876
CV	73.05	42.36	55.07	126.4	59.52	27.00	102.4	37.96	108.8	38.00	49.23	95.53
Location C. Rice												
A	0.735	60.750	0.060	19.40	0.225	117.60	0.120	27.900	0.015	169.24	0.255	42.135
AB	0.195	43.470	0.450	4.500	0.240	32.625	1.240	5.580	0.075	170.04	1.080	21.660
Bt1	0.105	35.805	0.810	7.245	0.795	2.670	1.425	4.125	0.030	35.400	1.785	9.810
Bt2	0.090	124.50	1.365	13.950	0.030	61.035	0.960	5.085	0.345	55.440	1.860	6.810
Mean	0.281	66.131	0.671	11.274	0.323	53.483	0.936	10.673	0.116	107.53	1.245	20.104
CV	102	60.92	82.64	59.57	114.0	91.50	60.61	107.9	133.0	67.13	60.06	79.72

The distribution of these micronutrients in the studied soils were quite low and most of them far lower their naturally occurring quantities in tropical agricultural soils as suggested by Rufus *et al.*, (2012) and Dhaliwal *et al.*, (2019). Mean Cu contents were as follows in the respective locations. Location A; 2.573, 1.646, 1.025 mg kg^{-1}; Location B; 0.349, 0.443, 0.953 $mgkg^{-1}$ and Location C; 0.281, 0.323, 0.116 mg kg^{-1} in the respective pedons of maize, cowpea and rice harvested plots respectively. However, some of the ranges of Cu found this study especially location A precisely, were higher than what has been reported (0.54-1.6 mg kg^{-1} Cu) in soils of the semi-arid parts of northern India (Katyal and Sharma, 1991) whereas those of Location B and C were almost of the same range with the above reports. Rufus *et al*,. (2012) obtained the 0.1M HCl extractable Cu ranges of 0.29-3.63 mg kg^{-1} at the lower Benue valley of central Nigeria which falls within the range of Cu content of the studied soils of Northern Guinea Savanna of Nigeria. Matijevic *et al.*, (2014) discovered a considerable increment in total Cu content of soils resulting from organic matter application.

Mean Fe content of studied soils are as thus; location A; 121.53, 88.905 and 83.66 mg kg^{-1}; location B; 59.760, 47.04 and 58.613 mg kg^{-1}; location C; 66.13, 53.483 and 107.13 mg kg^{-1} in their pedons 1, 2 and 3 respectively (Table 1). Hamza (2008) gave the critical Fe level to be 100 mg kg^{-1} and toxicity to be above 400 mg kg^{-1}. Most of the soils in the studied location had their Fe contents below the critical levels except pedon 1 of location A (maize harvested field) and pedon 3 of location C (rice harvested field) where mean Fe contents were above 100 mg kg^{-1} indicating that Fe deficiency may be a threat to crop productivity of the studied soils. The redoximorphic properties and soil pH are among key components that determine the characteristics of Fe in soils. Formation of weakly composed Fe compounds (ferrihydrite) is encouraged by pH of 6.5 – 7.0, while more acidic and reduced conditions promote the mobilization of Fe minerals. Hamza (2008) noted that formation of solution in soils by Fe is an essential parameter that causes Fe deficiency in crops, common in soils dominated by calcium carbonate. Fe solubility reduces considerably in well aerated soils, as Fe is available in low soluble Fe^{3+} oxides and hydroxides. Hamza (2008) further stated that the alterations hinge on soil reactions and OM content, salt and temperature of the soil. Moreover, poorly aerated condition, common in compacted soils may lead to more solubilization of Fe, which may encourage Fe deficiency due to many tender roots getting injured or even destroyed. This ultimately decreases the absorptive potential of the whole root system. Freeing of Fe as a result of disintegration of rock materials is a very gradual procedure driven mainly by pH and O_2 concentration and by the dissolution–precipitation phenomena (Mengel, 1994). After aggregation due to weathering, the fate of Fe^{2+} is controlled by the oxidation-reduction reactions as well as pH status of the soil. Fe^{2+} released from primary minerals is readily oxidized under aerobic conditions and pH ranging from 5 to 8 (Dhaliwal *et al.*, 2019).

Table 2: Ranges of Micronutrients distribution in studied soil (mgkg^{-1})

Micronutrients	**Cu**	**Fe**	**Zn**	**Mn**	**Cu**	**Fe**	**Zn**	**Mn**	**Cu**	**Fe**	**Zn**	**Mn**
	Pedon 1				**Pedon 2**				**Pedon 3**			
Location A. Maize												
Highest	3.180	235.47	2.970	100.40	2.085	163.86	1.890	42.330	1.515	138.54	1.395	31.665
Lowest	1.980	73.620	1.305	6.630	1.230	37.710	0.480	2.145	0.525	51.840	0.210	10.650
Mean	2.573	121.53	1.950	34.121	1.646	88.905	0.990	14.813	1.025	83.660	0.670	18.055
CV	29.22	63.10	40.19	130.2	48.3	59.96	64.47	126.6	67.04	57.05	94.83	65.36
Location B. Cowpea												
Highest	0.585	96.900	0.390	54.180	0.810	58.155	0.630	19.020	0.345	91.095	0.900	36.120
Lowest	0.045	40.695	0.150	5.895	0.135	33.135	0.030	8.565	0.075	40.140	0.330	6.600
Mean	0.349	59.760	0.214	18.728	0.443	47.040	0.330	12.225	0.953	58.613	0.596	14.876
CV	73.05	42.36	55.07	126.4	59.52	27.00	102.4	37.96	108.8	38.00	49.23	95.53
Location C. Rice												

Highest	0.735	124.50	1.365	19.40	0.795	117.60	1.425	27.900	0.345	170.04	1.860	42.135
Lowest	0.090	35.805	0.060	4.500	0.225	2.670	0.120	4.125	0.015	35.400	0.255	6.810
Mean	0.281	66.131	0.671	11.274	0.323	53.483	0.936	10.673	0.116	107.53	1.245	20.104
CV	102	60.92	82.64	59.57	114.0	91.50	60.61	107.9	133.0	67.13	60.06	79.72
Micronutrient distribution in tropical agricultural soils												
Dist. In Soils*	2-100	20,000–550,000	10-300	450–4000	2-100	20,000–550,000	10-300	450-4000	2-100	20,000–550,000	10-300	450–4000
Critical limits	2-100	100-400+	10-150++	80 – 140+	2-100	100-400+	10-150++	80 – 140+	2-100	100-400+	10-150++	80 – 140+

*Micronutrients distributions in tropical agricultural soils (Dhaliwal *et al.*, 2019), +Hamza (2008); ++Obasi (2015)

From table 2, there is an obvious deficiency of Zn in all pedons studied in the various cropping locations according to Dhaliwal *et al.*, (2019) who gave Zn distributions of tropical soils to be in the range of 10 – 300 mg kg^{-1}. Obasi (2015) gave the critical limits of Zn as values less than 10 mg kg^{-1} whereas toxicity level may be as high as above 1500 mg kg^{-1} in tropical agricultural soils. The highest Zn values obtained were 2.97, 1.89 and 1.395 mg kg^{-1} on the topmost horizons of maize harvested pedons. For cowpea and rice locations pedons were 0.39, 0.63, 0.90 and 1.365, 1.425, 1.86 mg kg^{-1} respectively indicating severe deficiency of Zn in the studied soils. Deficiency of Zn has been a serious threat in in developing countries which depend mostly on cereals to fulfil their dietary needs and about half of the world population is found to be involved in this challenge (Cakmak, 2008). This concern is increasing on daily basis as Zn keeps playing significant position in biological activities of plants and human food needs being regarded as an essential micronutrient for growth and development (Alloway, 2008). Zn deficiency has ranked fifth as part of major causes of death and various sicknesses in sub-Sahara Africa and elsewhere in the world due to consumption of staple grains with low Zn contents such as rice [*Oryza sativa* L.], and maize [*Zea mays* L.] (Yang *et al.*, 2007). Therefore, stepping up Zn content in edible plant parts is of supreme importance in agricultural productivity to battle high level Zn deficiency in human nutrition across the globe (Cakmak, 2008).

Manganese (Mn) distribution of the studied soils could be said to be low considering the critical limits of (80 – 140 mg kg^{-1}) documented by Obasi (2015). Ranges of Mn distributions in pedons with highest Mn contents in each cropping locations are as thus; Maize; (6.63 – 100.04 mg kg^{-1}); Cowpea (5.895 – 54.18 mg kg^{-1}) and Rice (6.81 – 42.135 mg kg^{-1}) (table 3). Low organic matter content of the studied soils may have been responsible for the low Mn content observed in the soils. Green manuring and organic matter availability can lead to an upsurge the Mn content in soils. Submerged conditions leads to a more valent forms of Mn like MnO_2, Mn_2O_3 and Mn_3O_4 to get reduced to Mn^{2+} form which is easily taken up by crops (Ponnamperuma, 1972). Rainfall duration in northern Guinea Savanna Nigeria is very short, about four months (May – August). Also the possibility of green manure application on Rigachikun soils is hampered due to its conflictive use in the feeding of domestic animals.

The mean micronutrient distributions on the cropping soils, indicated that maize harvested soils (location A) had more Fe content in their respective pedons (121.53, 88.91, 83.66 mgkg^{-1}). This was followed by rice harvested soils in location C pedons (66.131, 53.48, 107.53 mgkg^{-1} respectively) while cowpea harvested soils in location B had lowest Fe content distribution indicating 59.76, 47.04, 58.56 mg kg^{-1} in their respective pedons although pedon 2 of rice harvested soil had a value lower than pedons 1 and 3 of cowpea soil. Mn had the next highest values after Zn distributing irregularly across study locations with highest occurring in maize harvested location A pedon 1(34.12 mg kg^{-1}). This was followed by rice harvested location C pedon 3 (20.10 mg kg^{-1}) and then cowpea location B pedon 1(18.72 mg kg^{-1}). Cu was the next highest in study locations pedons especially in maize (location A) and cowpea (location B) harvested soils while an irregular distribution of Cu with Zn was noticed at the rice harvested soil in location C. The Cu respective pedon values are as thus; maize (location A): 2.57, 1.65, 1.025 mg kg^{-1}, cowpea (location B): 0.349, 0.443, 0.953 mg kg-1, and rice (location C): 0.281, 0.323, 0.116 mg kg^{-1}. Mean Zn distributions had the lowest values in all locations though irregularly distributed with Cu especially in rice loction C. Pedon Zn contents in various locations are as thus; maize (location A): 1.95, 0.99, 0.67 mg kg^{-1}, cowpea (location B): 0.214, 0.33, 0.596 mg kg^{-1}, and rice (location C): 0.671, 0.936, 0.125 mg kg^{-1}. There is obvious deficiency of micronutrients in all studied locations as means obtained were lower than critical limits established (Hamza 2008; Obasi 2015). Values obtained were in consonance with those of other studies in northern guinea savanna of Nigeria (Oluwadare *et al.*, 2013). Deficiency of these nutrients may pose serious challenge to crop productivity and human health. Deficiency of Zn has been a serious threat to the growing third world populations ranking 5th causes of death due to consumption of staple grains with low Zn contents (Yang *et al*., 2007).

4. CONCLUSION

There was micronutrients decrease down the profile in all studied locations with Cu and Zn showing an irregular pattern in all pedons of rice harvested soils in location C. Mn only had significant and positive correlations with all other micronutrients (Cu, Fe and Zn) but non-significantly correlated with other soil properties. Micronutrient content of the studied soils were low and most below the critical limits of tropical soils. Constant crop removal, cattle grazing, burning of crop residues and erosion among others have contributed to low micronutrient contents. Inorganic fertilization application, a common practice in soils of northern guinea savanna have not yielded appreciable outcomes in micronutrients content and crops sustainability. Activities that will conserve organic matter such as accumulation of litter from harvested crops and alternative means of cattle rearing such ranching rather than freelance grazing should be employed, as efforts to replenish micronutrients through fertilization has not yielded the desired results.

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Characterization and Classification of Soils of the Rivers State University Teaching and Research Farm, Port Harcourt, Southern Nigeria

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ABSTRACT

This study was conducted to characterized and classified soils of the Teaching and Research Farm, Rivers State University, Port Harcourt. It covers 30 hectares of Land. A rigid grid soil survey method at very detailed level (100 x 100)m (1 ha) with two mapping units identified and delineated and each mapping unit, were represented by a soil profile that was described from bottom to the top of the profiles to avoid contamination. Soil samples were collected for laboratory analysis from the various horizons identified. The results obtained, showed that the soils were Inceptisols/Cambisol at order level, Udepts at suborder level, Eutrudepts Great group level and Typic Eutrudepts at subgroup level. Thus, soils of Teaching and Research Farm, Rivers State University, Port Harcourt which are largely Inceptisols/Cambisols, were greatly influenced by the drainage pattern, parent materials, climate especially rainfall and the vegetation of the area coupled with the geologic material, the sedimentary rocks that was weathered into coastal plain sands and buried under alluvium at varying degrees at different places in the study area.

Keywords: Characterization and Classification, Inceptisols, Rivers State University, Teaching and Research Farm, Udepts.

INTRODUCTION

Soil characterization and classification is a land evaluation assessment process that help to identify limiting qualities of soils and thus, provide a good basis to advise the farmers on appropriate land management practice to be adopted for optimum crop production (Peter, *et al*, 2021).Soil characterization, classification and evaluation help in establishing soil database for proper understanding of soil resources within our environment and for judicious uses of land resources (Jagdish et al. 2009; Udoh and Lekwa, 2014 and Peter and Umweni, 2021a). Proper soil characterization procedure provides the building block for understanding and appreciating the soil, and further classification. To minimized damage to soils and it environment, there is need for proper soil characterization and classification according to the proposed kind of used.

This is because, soil characterization and classification provides key information on the ability of land resources (soils) for sustainable crop production (Peter and Umweni, 2020a); thus, the classification of soils is usually done based on soil properties described in terms of their various diagnostic horizons and identifiable properties that are measurable in situ the field (Peter and Umweni, 2020b). Lack of soil characterization becomes obstacle to utilize the soil identify its production potentials and adaptation of better management practice to increase soil productivity. Soil resource inventory through characterization of the resources provides an insight into the potentials and limitations of soils (Arunkumar, *et al*, 2002). Generally, most lands in Nigeria are put to use without any form of land evaluation and sometime available land evaluation results are not utilized. In farming, risk is reduced by matching the requirement of land use to the land qualities, thus predicting the potential of an agricultural land (Musa *et al*, 2013; Peter and Umweni, 2021a). It also involves the interpretation of soil survey data in order that every hectare of land should be used in accordance to with it capability, suitability and limitation (FAO, 2006 and Peter *et al*, 2019). According to Rossiter, (1996) and Peter and Umweni, (2020a), Soil characterization and classification is procedure involving the use of scientific procedure essential to assess and determined the parent material from which the soils were formed and the potential of such soils for agricultural production, engineering, urban development, pollution control etc (Onweremadu et al, 2009 and Peter et al, 2022 a). Therefore, to maintain sustainable agriculture and land use planning, proper soil investigation need to be embarked upon using soil characterization and classification procedures at both local and international level (Sereke, 2002 and Peter and Umweni, 2020b). Thus, the main aim and objective of this research was to characterized and classified soils of the Rivers State University Teaching and Research Farm, Port Harcourt, Southern Nigeria

MATERIALS AND METHODS

The Teaching and Research Farm belong to the Faculty of Agriculture, Rivers State University, Port Harcourt, Nigeria. This land has been under intensive cultivation since the establishment of the University in 1979. It lies between latitude 4^0 $40^1 50^{"}$N and $4^0 51^1 40$''N and longitude $6^0 57^1 30$''^{o}E and 7^0 5^1 0''^{o}E. It has mean annual rainfall of 2000 – 3000mm and mean annual temperature of 25 – 28^{o}C (Peter and Aaron, 2019; Ikati and Peter 2019). The relative humidity varied between 70 – 85 % depending on season of the year. The study area also experienced a period of low precipitation (dry season) commonly called harmattan period (late November to February). The vegetation of the study area as described by Ikati and Peter, (2019) and Peter and Aaron, (2019) is that of the humid tropical ever green, but tremendously altered as a result of continuous cropping system normally practiced in the area. The study area is underlain by the coastal plain sands and alluvium of marine deposits (Peter and Aaron, 2019).

Field Study

A detailed soil survey was carried out on the 30 hectares of land covering the Teaching and Research Farm. The land area was geo-referenced and digitized in an Arc map environment to form the shape field of the study area. The digitized map was gridded using the rigid grid method of detailed soil survey measuring 100 m x 100 m (1 ha) per auger boring point. Thirty (30) auger boring points were identified, and auger boring was done at depth intervals of 0 – 30cm, 30 – 60cm, 60 – 90cm and 90 – 120cm. Soil samples were described in the field. Soil morphologically properties were ascertained in situ using soil colour, texture (by hand feeling), structure, drainage, presence or absence of mottles, concretions and other morphological properties. Soils with identical properties were assembled to form mapping units. And from the grouping based on similarities, two mapping units were identified and delineated. Soil profiles pit of 2m x 2m x 2m were dug in each of the mapping unit (pedon) and described starting from bottom to top according to FAO (1976) and Anderson and Ingram (1993).

Laboratory Analysis

Soil particle size was determined by the hydrometer method according to Bouyocus, (1962). Bulk density was determined by the clod method as described by Blake and Hartage, (1986). Soil reaction (pH) was determined in 1:1 water ratio using glass electrode pH metre (Hossner, 1996). Electrical conductivity was carried out using electrical conductivity meter; while soil organic carbon content was determined by Walkey and Black (1934) method. Total nitrogen was determined by the Micro Kjeldal digestion method (Hossner, 1996; Ibitoye, 2008). Available Phosphorus was also determined by the Bray-1 method (Bray and Kurtz, 1945). Exchangeable bases (Ca, Mg, K and Na) were all determined using Ammonium acetate saturation method (Ibitoye, 2008). Exchangeable acidity was determined using the EDTA Titration method (Ibitoye, 2008); while Effective Cation Exchange Capacity (ECEC) was determined by the summation of total exchangeable bases and total exchangeable acidity and Percentage Base saturation was determined by expressing the sum of total exchangeable bases as a function of cation exchange capacity.

$$\%\, Base\ Saturation = \frac{Total\ Exchangeable\ Bases}{CEC}\ x\ 100$$

Soil classification

Soils of the Teaching and Research Farm were classified using two conventional methods of the soil taxonomy of the United States Department of Agriculture (2014) and correlated with the World Reference Base for Soil Resources (2014).

RESULTS AND DISCUSSION

Morphological properties of soils of the study area

Soil morphological characteristics of the study area are shown in Table 1. It was observed that soil depths of the both pedons were deep (200 cm). It was also observed that the various peodns have different soil colour matrix. Pedon 1 had soil colour ranging from very dark greyish brown (10YR3/2) in the Ap1- horizons to strong brown (7.5YR 4/6) (moist) in the Bt2 – horizon, while in pedon 2, all the horizons had strong brown colouration (moist). The soils were well drained and the drainage condition of the soils in the study area accounted for observable changes in soil colours in the study area. This collaborates with the findings of Esu *et al*, (2008), Dumba and Peter, (2020) and Peter and Umweni, (2020b). The brownish colouration in most of the horizons was due to the presence of organic matter as the most influential colouring agent in the surface soils. This is also in line with the reports of Nuhu, (1983), Donald (2017), Peter and Umweni, (2020a), Peter *et al*, (2021), Peter *et al*, (2022a) and Peter *et al*, (2022b). Again, the degree of peodogenic activities (illuviation and eluviation) in the soils also contributed to the colour matrix of each pedon (Donald, 2017). Soil textural class for pedon1 ranged from sandy loam at surface horizon (Ap1) to sandy clay loam at subsurface horizons (Bt2 - horizon); while it varies from loamy sand to sandy clay loam in pedon 2. Soil textures in both pedons had sub-angular blocky to blocky structures, soil consistence were friable, sticky and plastic when moist depending on the depth with root abundance at soil surface region.

Physical properties of soils of the study area

Table 2 shows the physical characteristics of soils of the study area. It reveals that soils of the study area across pedon were well drained as indicated by the colour. Sand fractions decreased from 832 g/kg to 692 g/kg with mean value of 748 g/kg down the profile depth in pedon 1. In pedon 2, sand fractions decreased from 852 g/kg to 692 g/kg with mean value of 752 g/kg. There were reductions in sand fraction down the profile with an increase at soil surface horizons. The increase in sand fractions at soil surface horizons could be attributed to erosion and eluviation of clay particles resulting to the sandy nature of the soils at the upper horizons (Donald, 2017). Silt fractions were 26 g/kg across the horizons in pedon 1, but ranged from 26 g/kg to 46 g/kg with mean value of 32.2 g/kg in pedon 2. The clay fractions of the soils increased from 142 g/kg to 282 g/kg in pedon 1; while the clay fraction value in pedon 2 increased from 102 g/kg to 282 g/kg. It was also observed that, clay fractions increased down the depth of the profile in all the pedons. The increase in clay fraction with depth might be attributed to eluviation-illuviation processes as well as the geologic materials from which the soils were formed. This is in line with the reports of Ekuo *et al* (2002), Esu *et al*, (2008), Chikezie *et al (*2009), Donald (2017), Peter and Umweni, (2020 b), Peter et al, (2021), Peter *et at*, (2022 a) and Peter *et al*, (2022 b). Soil bulk density values in the study area were 1.59 to 1.89 g/cm^2 in pedon 1 and 1.63 to 2.09 g/cm^2 in pedon 2. The soil bulk density (1.75 – 1.8 g/cm^2) of the study area were higher than critical limits for root restriction as reported by Soil Survey Staff (2006). The increase could be attributed to the activities of farm machinery over time (Peter et al, 2022 a).

Chemical properties of the Study Site

Table 3 showed some of the chemical properties of soils in the study area. Electrical conductivity (EC) varied from 19.16 – 42.72 ds/cm^2 in pedon1 and 12.33 – 18.33 ds/cm^2 in pedon 2. Soil reaction (pH) in water (H_2O) ranged from strongly acidic to moderately acidic when compared to the rating of Singer and Munns (1999). Pedon 1 had soil pH (H_2O) that varied from 4.75 to 5.53; while pedon 2 had H values ranging from 4.59 to 5.16. The acidic nature of the soils could be attributed to erosion and high rate of leaching in the as a result of the high rainfall (2000 – 3000 mm) experienced in the area. This is in conformity with the finding of Silver *et al* (2004) and Peter *et al* (2022). Soils of the study area had very low organic carbon ranging from 0.27 – 0.98 g/kg in pedon 1 and pedon 2 recorded organic carbon level of 0.31 – 0.43 g/kg. it was observed that surface soils had more organic carbon than the subsurface soils. This could be attributed to deposition of organic materials on the surface soils leading to an increase in in the organic carbon content at soil surface horizons. Total nitrogen ranged between 0.01 – 0.07 g/kg in pedon 1 and ranged between 0.01 0.14 g/kg in pedon 2. The values were rated very low when compared to available standard as reported by Douglas and Peter (2016). The available P content in both pedons ranged from 1.75 – 48.59 mg/kg. It was also observed that available P level was above the minimum critical level requires for optimum crop productivity as stated by Oko-oboh *et al* (2018) and Peter *et al* (2021). CEC varied from 4.89 – 6.92 cmo/lkg in pedon 1 and 4.20 – 7.34 cmol/kg in pedon 2. CEC was moderate both in at surface soil levels but there was no increase with depth in pedon 1. This contradicted the finding of Magaji (2018), but there were increase in the CEC level with depth in pedon 2 conforming to the report of Magaji (2018). The concentration of exchangeable bases in soils of the study area showed that calcium in both pedons were medium (2.8 – 4.6 cmol/kg and 1.8 – 4.8 cmol/kg), magnesium was medium to high in both pedons (0.6 – 1.2 cmol/kg and 0.1 – 2.2 cmol/kg); while Potassium was low to medium in pedon 1 (0.11 – 0.21 cmol/kg) and low in pedon 2 (0.08 – 0.10 cmol/kg) The low to medium level of exchangeable bases (Ca, Mg and K) could be as a result of pedogenic process occurring in the soils (Obi et al, 2001) and the continuous cropping system and leaching and the origin (parent materials from where the soils were formed Peter et al, (2022b). Pedon 1 and 2 had high percent base saturation (87.68 – 94.69 %).

Soil Classification

The soils of the study area were classified according to the latest criteria laid down in key to Soil Taxonomy (USDA) Soil Taxonomy/Soil Survey Staff (2014) and FAO/ISIC/IUSS World Reference Base for Soil Resources (2014). Based on the morphological, physical and chemical properties the soils were classified at Order, Suborder, Great group and Subgroup level. Pedons 1 and 2 showed the development of colour and structural weak appearance of cambic B-horizons produced by soil forming factors and showed no evidence of accumulation clay, iron oxide, aluminum oxide or organic matter in sub-soils and they also have no distinct pedogenic diagnostic horizon, rather they possessed a cambic subsurface horizon with base saturation < 50% (by NH4OAc) in soil horizon thus fell under the inceptisols**.** Based on their hyperthermic soil temperature and udic moisture regime as a result of seasonal dryness for at least 90 days or more water cumulative days per year, they were placed under the Udepts suborder. The base saturation by NHOAc of 60 % or more in one or more horizons at a depth of 25 – 75 cm from the mineral soil surface qualified both pedon 1 and 2 into the Eutrudepts Great group. Pedon 1 and 2 also fits into Typic Dystrudept subgroup, this is because, they are moderately drained, and are not saturated with in any layer within 100cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have an ochric, kandic and or argillic horizons with regular decrease in soil organic carbon content. Using World Reference Base (FAO/ISIC/IUSS) (2014), both pedon 1 and 2 corresponds to Haplic Ferralic Cambisol

CONCLUSION

The soils of the Teaching and Research Farm had been under intensive crop cultivation due to an increasing student's population and urbanization pressure worldwide on land resources and, also there is need to increase crops cultivation to provide food for the teaming population. To achieve this task, it is imperative to obtain detailed and reliable information on the types of land resources (soils) in an area and their suitability. These soils of Teaching and Research Farm, Rivers State University are largely Inceptisols/Cambisols and these soils could be sustained for reasonable agricultural productivity. However, they require careful management to ameliorate acidity and nutrient deficiencies.

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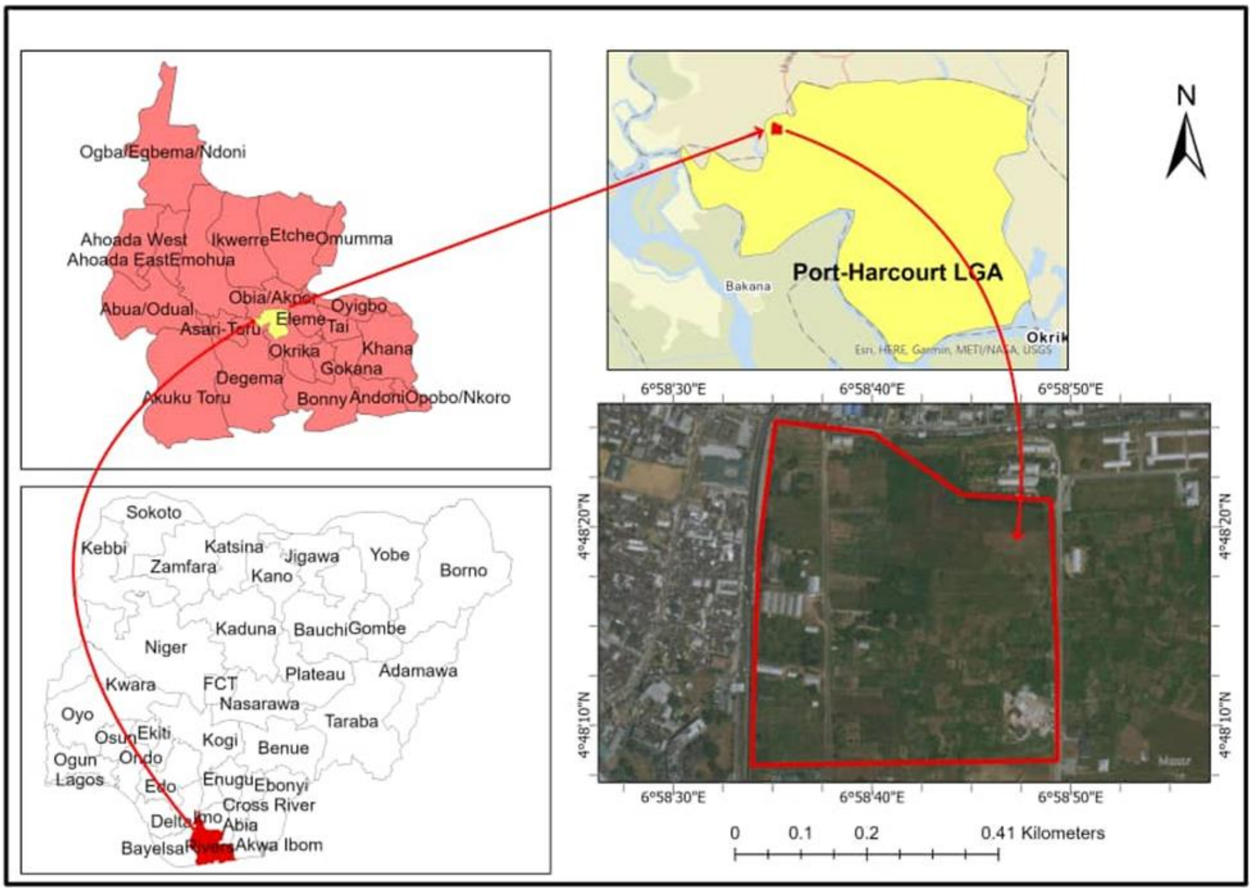

Fig 1: Map of the study area

Table 1: Morphological Properties of Soils in the Study Area

Horizon	Depth (cm)	Color (moist)	Texture	Structure	Consistency			Features
					Moist		Wet	
PEDON 1								
Ap1	0-21	10YR 3/2 very dark grayish brown	sl	sbk	Friable	Sticky	Plastic	Abundant root
Ap2	21 – 34	10YR 3/8 strong brown	scl	bk	Friable	Sticky	Plastic	Abundant root

Ab	34-55	10YR 4/6 dark yellowish brown	scl	bk	Friable	Sticky	Plastic	Abundant root
Bt1	55-87	7.5YR 5/8 strong brown	scl	bk	Friable	Non sticky	Plastic	No root
Bt2	87-200	7.5YR 4/6 strong brown	scl	bk	Friable	Highly sticky	Plastic	No root
PEDON 2								
Ap	0-23	7.5YR 5/6 Strong Brown	ls	sbk	Friable	sticky	Plastic	Less root
AB	23-80	7.5YR 4/6 Strong Brown	scl	bk	Friable	Non sticky	Plastic	Less root
Bt1	80-200	7.5YR 5/6 Strong Brown	scl	bk	Friable	sticky	Plastic	No root

sl = Sandy Loam, scl = Sandy Clay Loam, ls = Loamy Sand, sbk = Sub-angular Block, bk= Blocky

Table 2: Physical Properties of Soils in the Study Area

Horizon	Depth (cm)	Sand	Silt	Clay	TC	Drainage	BD
		→	g/kg^{-1}	←			gcm^3
PEDON 1							
AP1	0-21	832	26	142	sl	well drain	1.89

AP2	21-34	752	26	222	scl	well drain	1.63
Ab	34.55	752	26	222	scl	well drain	1.79
Bt1	55.87	712	26	262	scl	well drain	1.61
Bt2	87-200	692	26	282	scl	well drain	1.54
	Mean	748	26	226			1.69
PEDON 2							
AP	0-23	852	46	102	ls	well drain	2.09
Ab	23-80	712	26	262	scl	well drain	1.79
Bt1	80-200	692	26	282	scl	well drain	1.63
	Mean	752.	32.6	215.4			1.84

TC= Textu ral Class, BD = Bulk Density

Table 3: Chemical Properties of the Soils in the Study Area

HORIZON	DEPTH (CM)	EC (ds/cm)	pH (H20)	OC (gkg^{-1})	TN	Av. P (mgkg-1)	CEC cmolkg^{1}	Ca	Mg cmolkg^{1}	K	BS (%)
						Pedon 1					
Ap1	0-21	42.70	5.41	0.66	0.07	48.59	6.10	4.6	0.6	0.11	87.68
Ap2	21-34	32.90	5.53	0.39	0.01	12.81	6.93	4.4	1.6	0.13	89.01
Ab	34-55	30.70	5.40	0.27	0.07	7.02	5.98	4.4	0.8	0.14	89.89
B_t1	55-87	53.60	5.45	0.31	0.07	17.54	5.73	3.2	2	0.21	94.69
B_t2	87-200	19.16	4.75	0.98	0.07	3.59	4.89	2.8	1.4	0.21	90.77
	Mean	35.81	5.31	0.52	0.056	17.91	5.93	3.88	1.28	0.16	90.41
	Pedon 2										
Ap	0-23	12.33	4.65	0.43	0.14	2.29	5.52	1.8	2.2	0.08	75.13

Ab	23-80	18.33	5.16	0.39	0.07	24.56	4.20	3.8	01	0.08	93.01
B_t1	80-200	12.49	4.59	0.31	0.01	1.75	7.34	4.8	1	0.10	81.77
	Mean	14.38	4.80	1.13	0.028	12.86	5.69	3.46	1.06	0.09	83.30

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EC: Electrical Conductivity, OC: Organic Carbon, Av. P: Available Phosphorus, CEC: Cation Exchange Capacity and

TN: Total Nitrogen

Suitability assessment of soils for coffee production in Epe Southwestern Nigeria

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ABSTRACT

Coffee production has contributed greatly to the economy and sustenance of livelihood. Therefore, suitability assessment of soils for its production cannot be overemphasized. Three mapping units were identified in the study area and one pedon established on each. Soil samples collected from each genetic horizon were analyzed for their physical and chemical properties. The result showed that the soils were sandy in texture, ranging in sand content from 492.0 to 852.0 g/kg, clay content ranged from 54.0 to 314.0 g/kg and silt content from 94.0 to 194.0 g/kg. The soils were slightly acidic (5.15 to 5.42). Soil organic carbon ranged from 1.20 to 16.20 g/kg. Nitrogen, Phosphorus and Potassium content of the soils ranged from 0.2 to 1.3 g/kg, 2.36 to 21.04 mg/kg and 0.09 to 0.33 cmol/kg respectively. The exchangeable content of calcium and magnesium ranged from 1.00 to 1.66 and 0.11 to 0.36 cmol/kg. The land use potentials for coffee was assessed using square root method (parametric method) of land suitability evaluation according to FAO framework. The result shows that the aggregate rating for both current (actual) and potential suitability are the same. The most suitable class (S1) was obtained at the lower slope while upper and middle slope were moderately suitable (S2). However, with proper fertility management, the soils would be highy suitable for *coffea robusta* production.
Keywords: soils, suitability assessment, coffee production

INTRODUCTION

Soil is an essential natural resource which is germane in plant and animal growth, therefore needs to be treasured. Land evaluation is the process of assessing the possible use of land for agriculture, forestry, engineering, industry, conservation and recreation purpose. It is the assessment of land for a specific type of land utilization such as rainfed farming, extensive grazing, irrigation and agriculture (Oluwatosin, 2005). It is essential to know appropriate areas for agricultural practices in order to improve crop production. Through this, land can be apportioned in terms of suitability for a specific purpose to facilitate for effective land use management and planning systems. Soil information gathered by systematic identification, grouping and delineation of various soils is therefore necessary when good interpretations towards land use potential are to be made (Balthaza *et al.*, 2003).

Coffee is one of the essential cash crops being exported. It is a source of income to farmers and a foreign exchange earner. It is also a source of industrial raw material and creates job opportunity for millions of people. Coffee is a perennial crop, which is productive for several years. It belongs to genus *Coffea* which is a member of the family Rubiaceae. Global annual consumption of coffee per capital is 4-5 kg on average (International Institute of Tropical Agriculture, 2021). International coffee organization (ICO) stated that about 1.4 billion cups of coffee is being consumed daily worldwide, while about 125 million people depend on coffee for their livelihood (Osorio, 2002). The first two types of coffee to be cultivated originated in Africa and they are *Coffea arabica* and *Coffea canephora* (*Coffea robusta*) (Negussie and Derese 2007). *Coffea arabica* which is cultivated on highland tropical and sub-tropical area, performs best at higher altitude and has lower caffeine content. The higher yielding robusta can be grown at sea level (lowland areas) and is generally used in instant coffee and in stronger roasts. Davis *et al.,* (2006) stated that *Coffea robusta* is extensively distributed, from West to East Africa in Ghana, Guinea, Guinea Bissau, Cote d'Ivoire, Liberia, Nigeria, Cameroon, Congo, Central African Republic, Democratic Republic of Congo, Gabon, Sudan, South Sudan, Tanzania, and Uganda and to the south of Angola.

Deficiency and imbalance of soil nutrients are one of the major constraints to production of crops in Nigeria. Little attention has been given to the suitability assessment of soils for coffee production. Therefore, assessment of soils in Nigeria to increase crop production is very essential. Hence, the need for this study. The objectives of this study is to evaluate the nutrient status of the soils and assess their suitability for *Coffea robusta* production.

MATERIALS AND METHODS

The study was carried out in Epe Local Government area of Lagos state, Nigeria. The location has a humid tropical climate characterized by distinct wet and dry seasons. The total annual rainfall based on 11 years climatic data was about 1800 mm (2010-2020), relative humidity was 86.58%, predominant annual wind direction was 226.43^o, while the mean annual temperature was 31^{o}C (NASA, 2020). Three mapping units (EP1, EP2 and EP3) were identified and representative pedons were established in each mapping unit. Geographical location of each pedon was recorded using GPS as follows: EP1 (Latitude 6°38′16.6″N and longitude 3°54′48.2″E), EP2 (Latitude 6°38′15.8″N and Longitude 3°54′52.0″E), and EP3 (Latitude 6°38′14.6″N and Longitude 3°54′53.9″E). The pedons were described according to FAO/UNESCO (2006) procedure. Bulk soil samples were collected from different genetic horizons identified within the pedons. The samples were analyzed for sand, silt, clay, pH (H_2O), total N, organic carbon (OC), available P, exchangeable K, Ca, Mg, Na, and percent base saturation using standard procedures. Using the method of Sys *et al.*, 1993, suitability of the soils for coffee production was assessed using parametric approach. Each pedon was assigned to suitability classes by matching their characteristics with the requirements for coffee production. Each feature was ranked using Square root method equation: $IP = A \times \sqrt{((B/100) \times (C/100) \times \ldots \times (F/100))}$. where; IP is the index of productivity, A is the overall lowest characteristic rating and B, C…F are the lowest characteristic ratings for each land quality group (Udoh *et al.*, 2006). Current and potential index of production for each pedon was calculated. In each pedon, only one member of each of the five land quality groups (climate(c), topography (t), wetness (w), soil physical characteristics(s) and fertility (f)) were used in the calculation because there were strong correlations among members of the same group (Ogunkunle 1993).

RESULT AND DISCUSSION

Morphological and physical properties of the soils

Generally, soil depth of the three mapping unit were moderate (92 – 110 cm) and well developed as evidenced by the presence of B (Argillic/Kandic) horizons with high base saturation (BS≥35%), which are characteristics of the Alfisols. Mapping unit EP1 was located at the upper slope with an elevation of 51 m while EP2 was located at the middle slope with an elevation of 3 m and EP3 located at the lower slope with an elevation of 21 m above sea level. The horizon boundaries were clear to gradual in distinctness and smooth to wavy in topography. The colour ranged from brown to reddish yellow in mapping unit EP1, reddish gray to pinkish gray in mapping unit EP2, while mapping unit EP3 varied from brown to light brown. The soil colour seems to be the function of chemical and mineralogical composition as well as textural make up of soils and conditioned by topographic position and moisture regime (Walia and Rao, 1997). The textural class of the soils ranged from loamy sand to sandy clay loam. Sand dominated the particle size distribution of the study area, this could be due to geological processes involving sorting of soil materials by biological activities, clay migration through eluviation and illuviation, or surface erosion by run off (Malgwi *et al.*, 2000). The sand content ranged from 492.0 to 852.0 g/kg; the silt content ranged from 94.0 to 194.0 g/kg while clay content varied from 54.0 to 314.0 g/kg. Its distribution in all the pedons was irregular.

Chemical properties of the soils

The soil pH of the soils in water was rated slightly acidic with pH ranging from 5.15 to 5.42. The pH range of 5.5 to 7.0 was established by Brady and Weil (2010) as optimum for overall satisfactory availability of plant nutrients. Organic carbon content decreased with increasing soil depth and ranged from 1.20 to 16.20 g/kg. The values were rated low irrespective of soil depth since the values were below the critical value of 30 g/kg suitable for ideal coffee production (Egbe *et al.*, 1989). Thus, management of organic matter for nutrient retention and for better aggregation to reduce susceptibility to runoff and erosion is required for sustainable production.

Nitrogen is an essential structural component of various compounds that are important for plant growth and development (Agbede, 2009). It is also important for carbohydrate utilization, growth and development. Total nitrogen content (0.2 to 1.3 g/kg) was moderate at the soil surface, the values were above the critical level of 0.9 g/kg Phosphorus (P) is a vital element in the establishment of new plantations due to its importance in cell division and root development (Akande *et al*., 2008). P (2.36 – 18.27 mg/kg) content of the soils was adequate for ideal coffee production. Its values were above the critical level of 6 mg/kg. Potassium (K) is necessary for formation and translocation of carbohydrates, cell division, regulation of osmosis or control of water in the plants and increases the resistance of some plants to certain diseases and insects attack as well as activator of various enzymatic systems (Ibiremo and Akanbi, 2015). Magnesium (Mg) is a major constituent of chlorophyll, it helps in seed germination, essential for photosynthesis and produces energy for the plants. Potassium (0.09 – 0.33 cmol/kg), Mg (0.11 – 0.36 cmol/kg) and Calcium (1.00 – 1.66 cmol/kg) were rated low, the values are below the critical value of 4, 8 and 8.9 cmol/kg respectively, for soils suitable for coffee (Egbe *et al*., 1989). Therefore, K, Mg and Ca based fertilizer should be applied on the studied soils for optimum production. Base saturation in the three pedons were rated high. Food and Agricultural Organization (1999) stated that soils with base saturation of >50 % are regarded as fertile soils, while soils with <50% are infertile. The exchangeable acidity (0.8 – 0.12 cmol/kg) inferred that acidity may not be a threat in the study area.

Suitability classes

Table 1 shows land use requirement for *Coffea robusta*, while Table 2 shows the assessment ratings resulting from matching land qualities with the properties of the soils. A land index was calculated from the individual ratings using the square root method (Sys *et al.*, 1993). The result shows that the aggregate rating for both current (actual) and potential suitability fell within the same suitability class (S2). The soils were placed at moderate to high suitability class for *Coffea robusta* production in the area.

Table 1: Land suitability requirements for *Coffea robusta* production

Parameter	**Suitability classes**				
	S1(100%)	S2 (85%)	S3 (60%)	N1 (40%)	N2 (20%)
Climate (C)					
Annual rainfall (mm)	1,600-2,400	1,400-2,400	>1,200	__	any
Mean annual temperature (°C)	>22	>20	>18	__	<18
Relative humidity (%)	45-80	35-90	30-100	__	any
Length of dry season (months)	1-2	2-3	3-4	__	>4
Topography (T)					
Slope (%)	<8	<16	<30	<50	Any
Wetness (W)					
Drainage	Well drained	Moderate	Imperfect	Poor	Very poor
Flooding	No	No	Slight	any	Slight
Physical soil characteristics(S)					
Soil depth (cm)	>150	>100	>50	>50	Any
Texture/structure	C+60s to SCL	C+60s to SL	C+60s to LFS	C+60s to LFS	Cm to Cs
Coarse fragments (Vol.%)	<15	<35	<55	<55	>55
Fertility characteristic (F)					

Organic matter (% C, 0-15cm)	>0.8	Any	__	___	___
Base saturation (%)	>20	Any	__	__	__
CEC (Meq/ 100 g soil)	>16	__	__	__	__

F1 = Slight, C+60s to SCL = Very fine clay blocky structure to sandy clay loam, C+60s to SL = Very fine clay blocky structure to sandy loam, C+60s to LFS = Very fine clay blocky structure to loamy fine sand, Cm to Cs = Massive clay to sandy clay. S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N1 = presently not suitable, N2 = permanently not suitable.
Source: Modified from Sys *et al*., (1993).

Table 2: Land suitability ratings for coffee production.

Land characteristics	Units	Pedon 1	Pedon 2	Pedon 3
Climate (C)				
Annual rainfall	mm	100(S1)	100(S1)	100(S1)
Mean annual temperature	°C	100(S1)	100(S1)	100(S1)
Topography (T)				
Slope	%	100(S1)	100(S1)	100(S1)
Wetness (W)				
Soil drainage		85(S2)	85(S2)	85(S2)
Flooding		100(S1)	100(S1)	100(S1)
Physical Properties (S)				
Texture		60(S3)	100(S1)	85(S2)
Soil depth	(cm)	60(S3)	60(S3)	85(S2)
Coarse fragment	%	100(S1)	100(S1)	100(S1)
Fertility Characteristics (F)				
Soil organic carbon (top soil)	%	100(S1)	100(S1)	100(S1)
Base saturation (top soil)	%	100(S1)	100(S1)	100(S1)
Aggregate suitability (actual)		**55(S2)**	**55(S2)**	**78(S1)**
Aggregate suitability(potential)		**71(S2)**	**71(S2)**	**85(S1)**

CONCLUSION

Current and potential suitability rating were similar. Pedon EP1 and EP2 were moderately suitable for *Coffea robusta* production, while pedon EP3 was highly suitable. Proper soil fertility management is required for the potentials of these moderately suitable soils to be raised to highly suitable class. Soil fertility of the soils should therefore be improved through good management practices such as incorporation of organic and inorganic fertilizers.

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Organic Matter Distribution and Crop Yield in Moringa Based Intercropping Systems in Southeast Nigeria

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ABSTRACT

Achieving food security for a rapidly growing population in Nigeria requires not only the intensification of food crops production on the existing cropland but also the use of sustainable agronomic practices, including appropriate cropping systems and soil fertility management strategies. In an attempt to achieve this, this experiment was conductedat the Teaching and Research Farm of Akanu Ibiam Federal Polytechnic, Unwana, Ebonyi State during 2015, 2016 and 2017 cropping seasons, to determine the effect of moringa based intercropping systems on organic matter distribution and nutrients release to growing crops.Randomized Complete Block Design (RCBD) with eleven treatments, comprising of sole and different intercropping systems of moringa (Mo) with maize (Ma), cassava (Ca) and sweet potato (Sp), each with three replications was used for the study. Pre-planting from the whole field and post-harvest soil samples from each treatment plot were obtained and analyzed in the laboratory for organic carbon and organic matter composition. Yield parameters including weights of cassava and sweet potato tubers, seed weight of maze and fresh leaf weight of moringa were obtained for each cropping season. All data collected were subjected to statistical analysis. Results showed significant ($P<0.05$) improvement on soil organic carbon and organic matter due to the inclusion of moringa in cassava, maize and sweet potato cropping systems and the increases were consistent with intercropping intensification and farming season. Thus, the treatment plot with Mo + Ca + Ma +Sp in the 2017 farming season gave the most appreciable increase in organic matter and organic carbon (5.03% and 4.08% respectively). However, yield components of the intercropped crops were not proportionally influenced with the intensification of moringa based intercropping systems. Sole cropping system for each crop had better yield than in the moringa based intercropping systems.

Keywords: Intercropping, Organic matter, Moringa, Cassava, Maize and Sweet potato.

INTRODUCTION

Nigeria still struggles on the path to food sufficiency despite several Government Agro-programmes and interventions.Attaining food sufficiency in Nigeria may remain a mirage without proper and sustainable cropping systems and soil management strategies. The soil is central to food production and healthy soils are essential to optimum crop productivity and food security. Widespread deficiencies in crop nutrients have been reported in most acid tropical soils of southeastern Nigeria (Azu *et al.*, 2019; Onwuka *et al.*, 2007). This has been attributed to partly the heavy tropical rains and poor agronomic and soil management practices (Osodeke, 1996). Therefore, understanding of soil nutrient dynamics and the formulation and adoption of viable and sustainable agronomic and soil management options is very crucial on the path to food security in southeastern Nigeria (Azu *et al.*, 2020).

Soil organic matter (SOM) and soil organic carbon (SOC) are the most important indicators of soil quality and productivity(Brady and Weil, 2008). Soil organic matter is byproducts of plants and animals and the remains of dead plants, animals and microorganisms. They play essential roles in the soil system including the biological, chemical and physical components of the soil (Brady and Weil. 2008). Mineralized organic matter apart from enhancing the biological and physical conditions of the soil, releases other essential nutrients to the soil. Maintaining organic matter in soil at optimum levels is important for soil fertility and productivity. Conservation agriculture which encompasses a range of such good practices through combining no tillage or minimum tillage with a protective crop cover and crop rotations and organic manure application are ways of improving soil organic matter (Farguharson *et al*, 2003; King *et al*, 2020). However, many common agricultural practices, especially ploughing, disc-tillage, vegetation burning, use of mineral fertilizer and other synthetic agro-inputs and intensification of cropping causes decline in soil organic matter, because the soil is exploited for crop production without restoring the organic matter and nutrient contents and maintaining a good structure, the nutrient cycles are broken, soil fertility declines and the balance in the agro-ecosystem is destroyed (Loveland and Webb, 2003; Bot and Beniter, 2005). Intensive farming through repetitive harvesting of crops, improper use of mineral inputs and inadequate effort to replenish organic matter to restore soil quality, distorts the natural soil processes including nutrient cycling, release and uptake by plants(Azu et al., 2008). Therefore, to ensure sustainability in crop production, there is urgent need to rebuild soil quality and health through appropriate farming systems that are sustainable, environmentally friendly, economically viable and productive. Against this background, this research work was designed to assess the effect of moringa based intercropping systems on t soil organic matter, organic carbon distribution and crop yield in Southeast Nigeria.

MATERIALS AND METHODS

The study was conducted at the Teaching and Research Farm of the Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic; Unwana, Ebonyi State, Nigeria(Lat. $05^0 20^1$N, Long. $07^0 02^1$E,Altitude 91m above sea level) during 2015, 2016 and 2017 cropping seasons. The area has annual rainfall range between 1500 – 3000mm, average temperature of $35^0$and relative humidity of 89 – 93%. The soil belongs to the order ultisol and has been classified as typic hapludult (Federal Department of Agriculture and land Resources 1985). The dominant vegetation is tropical rainforest that is tending towards derived savanna (Azu *et al.*, 2018). The experimental site had been left fallow for one year. Pre-planting soil samples taken at 0-20cm randomly from site was analyzed in the laboratory for organic matter and organic carbon according to standard methods.

A Randomized Complete Block Design (RCBD) with three blocks was used for the study. The experiment covered a total land area of0.102ha. Each block consisted of 11 plots measured 5m x 4m in area with spacing of 1.0m between plots and 2.0m between blocks. Eleven (11) treatments in total comprising of Mo, Ca, Ma, Sp, Mo +Ma,Mo + Ca, Mo + Sp, Mo + Ca + Ma, Mo + Ca + Sp, Mo + Ma + Sp and Mo + Ca + Ma + Sp.

Pre soil samples at 0 – 20cm depth were randomly taken at 4 points of the site after clearing, and the samples were bulked together for analysis. However, post composite soil samples were also collected on the site to determine the percentage of organic matter and organic carbon. Before planting, seed viability test on Moringa and maize was done and the seeds were planted 3 per hole at a distance of 1m × 1m at a depth of 3cm. On emergence, the seedlings were thinned down to 1 plant/stand and the thinned down seedlings were used as mulch materials. Cassava and Sweet potato stems and vines were cut at 25cm long with at least 5 nodes, and were planted at 1m × 1m apart, respectively. At harvest, yield data comprising of weight of cassava and potato tubers, weight of maize seeds and fresh weight of moringa leaf were measured. Also, post-harvest soil samples from each plot were taken and analyzed for organic matter and organic carbon according to Walkley and Black (1964) as modified by Udo *et al*., (2009). All data collected were subjected to statistical analysis of variance (ANOVA) as described by Akindele (2004).

RESULTS AND DISCUSSION

Organic Matter (%) and Organic Carbon (%) Composition of the Site before Planting at 2015, 2016 and 2017 Cropping Seasons is presented in table 1.Results showed that organic carbon and organic matter were relatively low prior the 2015 cropping season (0.90 and 1.62% respectively).

Table 1: **Organic Matter (%) and Organic Carbon (%) Composition of the Site before Planting at 2015, 2016 and 2017 Cropping Seasons**

Cropping Year	Organic matter (%)	Organic carbon (%)
2015	1.62	0.90
2016	3.27	1.94
2017	3.73	2.10

Cropping systems and climatic variables may have been responsible for this result. Osodeke and Ubah have previously reported low organic matter in acid soils of southeastern Nigeria. However, the concentration of both nutrients increased proportionally in 2016 and 2017 cropping seasons. The inclusion of moringa in the cropping system may have influenced this observed increase. Apart from the medicinal benefits of moringa, studies on moringa have shown that it has the ability of enhancing soil fertility status. Aze *et al*, (2020) and Essien *et al* (2015) had earlier reported increased soil fertility due to inclusion of moringa leaves compost in soil fertility management, leading to increased crop yield.

Results showed significant ($P<0.05$) improvement on soil organic carbon and organic matter due to the moringa cassava, maize and sweet potato intercropping systems and the increases were consistent with intercropping intensification and farming season (Table 2). Sole cropping treatment systems (SMo, SCa, SMa, SSp) produced the lowest values for organic matter and organic carbon. Thus, the treatment plot with Mo + Ca + Ma +Sp in the 2017 farming season gave the most appreciable increase in organic matter and organic carbon (5.03% and 4.08% respectively).

Table 2: Effect of Moringa Based Intercropping Systems on Organic Matter (%) and Organic Carbon (%) Composition during 2015, 2016 and 2017 Cropping Seasons

	2015	2016	2017	2015	2016	2017
Treatments	Organic matter (%)			Organic carbon (%)		
SMo	1.43	1.87	2.40	0.70	1.84	1.96
SCa	1.52	1.70	2.38	0.45	1.63	1.60
SMa	1.31	1.60	2.34	0.15	1.45	1.57
SSp	1.20	1.32	2.27	0.10	1.40	1.43
Mo + Ma	2.13	3.33	4.80	1.08	1.96	2.10
Mo + Ca	2.73	4.45	5.60	1.18	2.00	2.34
Mo + Sp	2.45	3.21	4.33	1.04	1.87	2.20
Mo + Ca + Ma	3.23	3.53	4.68	1.28	2.35	3.06
Mo + Ca + Sp	3.65	4.03	5.23	1.19	2.09	3.00
Mo + Ma + Sp	3.33	3.56	4.94	1.23	2.01	3.00
Mo + Ca + Ma + Sp	4.51	4.88	5.03	1.84	2.45	4.08
LSD (P≤ 0.05)	0.05	0.16	0.56	ns	0.02	1.23

SMo = sole moringa, SCa = sole cassava, SMa = sole maize, SSp = sole sweet potato, Mo = moringa, Ca = cassava, Ma = maize, Sp = sweet potato

The increase in organic matter and organic carbon in 2016 and 2017 cropping seasons with intercropping intensification could be an indication that within the period of cultivation, the litter falls from moringa and other crop leaves had decomposed to enrich the soils with organic matter (Brady and Weil, 2000).

The effect of moringa based intercropping systems on yield of moringa, maize, cassava and sweet potato is shown in table 3. Apart from yield of moringa in 2015 and 2017 cropping seasons, the yield of the crops both in sole cropping and intercropping systems, irrespective of the cropping season were statistically ($P<0.05$) influenced by the intercropping system. However, yield components of the intercropped crops were not proportionally influenced with the intensification of moringa based intercropping. Sole cropping system for each crop had better yield than in the moringa based intercropping systems. This result indicated that organic matter and organic carbon were not proportional to yield. The slow mineralization of organic matter to release nutrients mostly in the intercropped plots and the possibility of nutrient competition in the intercropped plots may have influenced this result. However, this suggests the possibility of potential residual nutrient effect for next crops. Azu.*et al.*, (2020), previously reported residual effects of moringa compost on soil organic matter.

CONCLUSION

Appropriate cropping systems provide useful index in soil quality management and sustainable crop production. Moringa based intercropping system improved the organic matter and organic carbon contents of soil. Sole cropping system for each crop had better yield than in the moringa based intercropping systems. Apart from promoting yields of sole cropping system, these intercropping systems have the potential of giving the soils long lasting fertility effects for sustainable crop production.

Table 3: Effect of Moringa Based Intercropping Systems on Crop Yields (t/ha) at Harvest during 2015, 2016 and 2017 Cropping Seasons

	Moringa			Cassava			Maize			Sweet potato		
Treatment	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
SMo	3.07	2.88	3.38	-	-	-	-	-	-	-	-	-
SCa	-	-	-	33.60	35.97	37.87	-	-	-	-	-	-
SMa	-	-	-	-	-	-	2.34	2.45	2.60	-	-	-
SSp	-	-	-	-	-	-	-	-	-	30.16	33.40	35.10
Mo + Ma	0.93	3.43	3.68	-	-	-	2.17	2.20	2.34	-	-	-
Mo + Ca	0.67	3.01	3.45	31.52	31.09	33.75	-	-	-	-	-	-
Mo + Sp	1.01	3.32	3.57	-	-	-	-	-	-	26.45	28.90	30.21
Mo + Ca + Ma	0.77	2.53	3.01	28.33	26.45	30.01	2.10	2.09	2.26	-	-	-
Mo + Ca + Sp	0.78	3.07	3.10	22.43	25.06	28.78	-	-	-	19.80	22.07	26.93
Mo + Ma + Sp	0.90	3.03	3.18	-	-	-	2.08	2.10	2.34	23.18	25.18	26.93
Mo + Ca + Ma + Sp	0.63	2.11	0.74	16.97	19.44	22.34	0.83	0.75	1.20	14.50	16.25	20.05
LSD ($P \leq 0.05$)	ns	0.67	ns	1.70	1.60	1.50	1.51	1.70	0.01	4.31	3.60	1.08

SMo = Sole moringa, SCa = sole cassava, SMa = sole maize, SSp = sole sweet potato, Mo = moringa, Ca = cassava, Ma = maize, Sp = sweet potato

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Bio-Fertilizer: A Key Tool For Sustainable Agriculture And Crop Productivity Among Farmers

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ABSTRACT

Bio-fertilizer is a component that carries living microorganisms that used into the soil as inoculants to provide certain nutrients for plants. This review portrays the role of bio-fertilizers in sustainable agriculture through meeting the needs of farmers and plant biologists whose work concentrate on creating clean and efficient means of improving soil quality by nourishing and maintaining the useful and natural flora of microorganisms. It shows the alternative use of fertilizer made from animal source in the field of agricultural management which exposes the potentials of the application in terms of increased nutrient profiles, plant growth and productivity as well as an improved tolerance to environmental stress. In view of these, this paper used analytical approach to review the term “bio-fertilizer,” Types of Bio-Fertilizers and their mode of work, differences between bio-Fertilizer and organic fertilizer, benefits of bio-fertilizer over chemical fertilizers and constraints to adoption of bio-fertilizer among farmers.

Keywords: Bio-fertilizer, agriculture,sustainability, environment, crops,farmer

INTRODUCTION

Agriculture has undergone series of advancement since the 12th century and is being practiced extensively throughout the world today. According to Food and Agricultural Development, 55% of people in Africa can earn a living through agriculture(Itelima , Bang, Onyimba, and egbere,2018). In Nigeria, agriculture is the basic means of livelihood for people in most areas especially the rural areas (Udemezue, Mmeremikwu, and Eluagu, 2021). Soil management strategies today are mainly relied on inorganic chemical-based fertilizers, which cause a serious problem to human health and the environment. Plants nutrients are essential for the production of crops and healthy food for the world’s ever increasing population. Biofertilizer has been identified as an alternative for increasing soil fertility and crop production in sustainable farming. The exploitation of beneficial microbes as bio-fertilizers has been important in agricultural sector due to their potential role in food safety and sustainable crop production(itelima,*et al*,2018; Udemezue, Mmeremikwu, and Eluagu, 2021).

Organic farming is one of such strategies that not only ensures food safety but also adds to biodiversity of soil (Raja,2013). The application of bio-fertilizer to the soil increases the biodiversity which constitutes all kinds of useful bacteria and fungi including the arbuscular mycorrhiza fungi (AMF) called plant growth promoting rhizobacteria (PGPR) and nitrogen fixers. There are so many microorganisms thriving in the soil, especially in the rhizosphere of plant(Udemezue, Mmeremikwu, and Eluagu, 2021).

With the current fall in price of crude oil which, today is Nigeria's major source of income; the President of Nigeria, Muhammadu Buhari GCFR emphasized that the nation must go back to agriculture, particularly crop farming which used to be the country's source of income before the discovery of crude oil . To get food to feed Nigeria's teaming population which according to Nigerian population census (2006) is expected to rise to 221 million by the year 2020, there is need for very fertile soils, for sustainable crop production(Itelima,*et al*,2018).

Agriculture plays an important role in meeting the food security of a growing human population, which has led to an increasing dependence on the use of chemical fertilizers and pesticides for increased productivity (Santos, Araujo, Leite ,2012)). Chemical fertilizers are industrially made substances which are composed of known quantities of nitrogen, phosphorus and potassium. The use of chemical fertilizers causes air and ground water pollution as a result of eutrophication of water bodies (Youssef and Eissa ,2014). According to Chun-Li, Shiuan-Yuh and ChiuChung (2014), though the practice of using chemical fertilizers and pesticides boosts soil acidification, it also poses the risk of contaminating ground water and the atmosphere. It also weakens the roots of plants thereby making them to be susceptible to unwanted diseases. As a matter of this, attempts have recently been made towards the production of nutrient rich high quality fertilizer (Bio-fertilizer) to ensure bio-safety. Therefore, Bio-fertilizer has been identified as an alternative to chemical fertilizer to increase soil fertility and crop production in sustainable farming. These potential biological fertilizers would play the key role in productivity and sustainability of soil and also protect the environment as ecofriendly and cost effective inputs for the farmers (Khosro and Yousef,2012).

Biofertilizers keep the soil environment rich in all kinds of macro and micro nutrients via nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil(Sinha, Valani and Chauhan,2014). Biofertilizers, when applied as seed or soil inoculants, multiply and participate in nutrient cycling and leads to crop productivity. Generally, 60% to 90% of the total applied fertilizer is lost and the remaining 10% - 40% is taken up by plants. Hence biofertilizers can be important component of integrated nutrient management systems for to sustaining agricultural productivity and a healthy environment (Adesemoye and Kloepper,2009;Sinha, Valani and Chauhan,2014;Udemezue,Mmeremikwu and Eluagu,2021).

Concept of bio-fertilizer

Biological activities are markedly increased by microbial interactions in the rhizosphere of plants. Organic fertilizers on the other hand are obtained from animal sources such as animal manure or plant sources like green manure. According to Khosro and Yousef(2012), the term bio-fertilizer may be used to include all organic resources for plant growth which are provided in available form for plant absorption through microorganisms or plant associations or interactions. Bio-fertilizer is simply a substance which contains living microorganisms which when applied to the soil; a seed or plant surface colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant(Raja,2013). It is a modernized form of organic fertilizer into which beneficial microorganisms have been incorporated (Udemezue, Mmeremikwu, and Eluagu, 2021). Bio-fertilizer is most commonly referred to as selected strains of beneficial soil microorganisms cultured in the laboratory and packed in suitable carriers.

Therefore bio-fertilizers are those substances that contain micro-organisms' living or cells that increase the nutrients of the host plant when applied to their seeds, plant surfaces or soil by colonizing the rhizospher of the plant. They can be explained as formulations containing either living or latent cells of efficient strains of microorganisms that facilitate the uptake of nutrients from crop plants. They carry out this pivotal role through interactions in the plant rhizosphere when applied through seed or soil. Microorganisms that commonly used as bio-fertilizer components are; nitrogen fixers (N-fixer), potassium and phosphorus solubilizers, growth promoting rhizobacteria (PGPRs), endo and ecto mycorrhizal fungi, cyanobacteria and other useful microscopic organisms. These potential biological fertilizers would play a key role in productivity and sustainability of soil and also in protecting the environment as eco-friendly and cost effective inputs for the farmers (Itelima,*et al*,2018). In view of these, this study used available literature to review the economic analysis of bio-fertilizer as an alternative use by the rural farmers.

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Types of Bio-Fertilizers and their mode of work

According to Itelima,*et al* (2018), Bio-fertilizers are classified into different types depending on the type or group of microorganisms they contain. They as follows:

Nitrogen fixing bio-fertilizers (NFB): Examples include Rhizobium Spp., *Azospirillum* Spp. and blue-green algae; these work by fixing atmospheric nitrogen and converting them to organic (plant usable) forms in the soil and root nodules of legumes, thereby making them available to plants. Nitrogen fixing bio-fertilizers are crop specific bio-fertlilizers.

➢ **Phosphate solubilizing bio-fertilizer (PSB):** Examples include *Bacillus* Spp., *Pseudomoona* Spp. and *Aspergillus* Spp. These work by solubilizing the insoluble forms of phosphate in the soil, so that plants can use them. Phosphorus in the soil occurs mostly as insoluble phosphate which cannot be absorbed by plants. However, several soil bacteria and fungi possess the ability to convert these insoluble phosphates to their soluble forms. These organisms accomplish this by secreting organic acids which lower the pH of the soil and cause the dissolution of bound forms of phosphate making them available to plants (Itelima,*et al*,2018).

- **Phosphate mobilizing bio-fertilizers (PMB):** Examples are *Mycorrhiza*. They work by scavenging phosphates from soil layers and mobilizing the insoluble phosphorus in the soil to which they are applied. Chang and Yang, (2014) stated that phosphorus solubilizing biofertilizer (PSB) sometimes act as phosphate mobilizers. Phosphate mobilizing bio-fertilizers are broad spectrum bio-fertilizers. Soil phosphorus mobilization and immobilization by bacteria.

- **Plant growth promoting bio-fertilizer (PGPB):** Examples of plant growth rhizobacteria are *Pseudomonas* Spp. etc: these work by producing hormones and anti-metabolites which promotes root growth, decomposition of organic matter which help in mineralization of the soil thereby increasing availability of nutrients and improving crop yield(Khosro and Yousef,2012; Bhattacharyya ,and Jha ,2012;Itelima,*et al*,2018). PGPB are crop specific bio-fertilizers.

- **Potassium solubilizing bio-fertilizer (KSB):** Examples include *Bacillus* Spp. and *Aspergillus niger*. Potassium in the soil occurs mostly as silicate minerals which are inaccessible to plants. These minerals are made available only when they are slowly weathered or solubilized. Potassium solubilizing microorganisms solubilize silicates by producing organic acids which cause the decomposition of silicates and helps in the removal of metal ions thereby making them available to plants. Potassium solubilizing bio-fertilizers are broad spectrum bio-fertilizers.

- **Potassium mobilizing bio-fertilizer (KMB):** Example of potassium mobilizing bio-fertilizer is *Bacillus* Spp. These work by mobilizing the inaccessible forms of potassium (silicates) in the soil. Some phosphate solubilizing bio-fertilizers such as *Bacillus* Spp. and *Aspergillus* Spp. has been found to mobilize potassium and also solubilize phosphorus.

- **Sulfur oxidizing bio-fertilizer (SOB):** Example of sulfur oxidizing microorganism is *Thiobacillus* Spp. These work by oxidizing sulfur to sulfates which are usable by plants.

Differences between Bio-Fertilizer and Organic Fertilizer

The term bio-fertilizer was used to include organic fertilizer.Technically; there is a big difference between them. Vishal and Abhishek(2014) in an attempt to distinguish between bio-fertilizer and organic fertilizer said “bio-fertilizers are microbial inoculants consisting of living cells of microorganisms like bacteria, algae, fungi, alone or a combination which may help in increasing crop productivity. Biological activities are markedly enhanced by microbial interactions in the rhizosphere of plants. Organic fertilizers on the other hand are obtained from animal sources such as animal manure or plant sources like green manure(Udemezue, Mmeremikwu, and Eluagu, 2021).

Benefits of bio-fertilizer over chemical fertilizers

The people's demand for fertilizer has greatly increased in the past few decades. According to Fertilizer Suppliers Association of Nigeria (FESPAN) (2007), Nigeria's fertilizer demand is estimated to be 12 million metric tons per annum. The use of inorganic fertilizers has been popularized in Nigeria and throughout the world because they are easily affordable and have the advantage of fast action due to their prompt release of nutrients. Despite this, there have been many findings on the demerits of inorganic fertilizers and these have indicated that they have disadvantages which cannot be overlooked. Most of the problems associated with harvested crops and some of the pollution of our natural environment occurred as a result of inorganic fertilizer use (Rosen and Horgan,2009;Itelima *et al*,2018). All the fertilizers used in Nigeria are imported and due to the high cost of importation, the price of the fertilizers becomes very high, thereby preventing resource poor farmers from accessing it. On the other hand, inorganic fertilizers when applied incorrectly, excessively and inadequately have negative effects. Many of the fertilizers imported into the country were wasted as farmers refused to purchase them due high cost and constraints associated with it(Itelima, et al,2018). However,different types of fertilizers are suitable for different soil types. To get fertilizers which will suit a particular soil, the soil needs to be analyzed. According to him, most of the fertilizers imported into the country are not suitable for our soil thereby giving negative rather than positive results; besides one requires a good knowledge before applying it but today, every illiterate farmer applies fertilizers without understanding how it works and its side effects. All these problems can however be avoided by the use of indigenous fertilizers which is environment friendly. These findings have led to the need for the provision of an environment friendly fertilizer known as bio-fertilizer. According to Itelima et al (Itelima *et al*,2018), yam farmers complained that the fertilizers were responsible for the early decay of harvested yam tubers. It is of no doubt that crops cultivated with inorganic fertilizers have fewer flavors, taste, and aroma than those cultivated without inorganic fertilizers. Excessive fertilizer application leads to salt burn and in most cases leads to the death of young plants(Laboski,2008; Itelima *et al*,2018). Due to they are non-biodegradable, long term use of inorganic fertilizers result in accumulation of harmful substances and acidification of the soil thereby causing a decrease in the fertility of the soil(Taylor, 1997;Itelima *et al*,2018).

Because of their high solubility in water, inorganic fertilizers applied to the soil could be leached deep into the soil (where plant roots cannot reach) and into underground water causing pollution. These fertilizers known as bio-fertilizers can achieve all that is achievable with inorganic fertilizers and even more without any side effects(Itelima *et al*,2018).Bio-fertilizers are environment friendly and do not cause pollution unlike inorganic fertilizers which often 'run off' into water bodies causing eutrophication and 'blue baby syndrome' (acquired methemoglobinemia) when the nitrate level is above 10 mg/L(Itelima *et al*,2018). The issue of excessive application does not arise in the use of bio-fertilizer and special skills are not required for its application. Bio-fertilizers have long lasting effects due to their slow nutrient release. The nutrients from biofertilizers are released to plants slowly and steadily for more than one season. As a result, long term use of bio-fertilizer leads to the buildup of nutrients in the soil thereby increasing the overall soil fertility. Moreover, bio-fertilizers have been found to help control of plant diseases such as pythium root rot, rhizoctonia root rot, chill wilt and parasitic nematode(Udemezue, Mmeremikwu, and Eluagu, 2021).Research has shown that some bio-fertilizers particularly those made with degraded tree barks and roots release chemicals that inhibit some plant pathogens. Disease control with bio-fertilizer has been attributed to four possible mechanisms: Successful competition for nutrients by beneficial microorganisms present in the fertilizer, production of antibiotics by the beneficial microorganisms, successful predation against pathogens by beneficial microorganisms, activation of disease resistant genes in plants by the microorganisms. Bio-fertilizer acts as a soil conditioner adding organic matter to the soil which helps to bind the soil particles together preventing soil eructing, desertification, and erosion while increasing the water retention capacity of the soil(Leaungvutiviroj,Ruangphisarn, Hansanimitkul ,Shinkawa and Sasaki,2010; Udemezue, Mmeremikwu, and Eluagu, 2021). It enriches the soil with beneficial microorganisms while boosting the already existing ones unlike chemical inorganic fertilizers which acidify the soil making it hard for microorganisms to survive(Leaungvutiviroj *et al*,2010). Bio-fertilizers contain a wide range of nutrients which are often absent in inorganic fertilizers (these include trace elements). Studies have shown that application of nitrogen fertilizer in some weather conditions cause emission of nitrous oxide which has a global warming effect potential 296 higher times than that of an equal mass of carbon dioxide (Itelima *et al*,2018;Udemezue, Mmeremikwu, and Eluagu, 2021). Methane emissions from crop fields (notably rice paddy fields) are increased by the application of ammonium based fertilizers whereas the composting of animal waste in a confined place or in an anaerobic condition (an important process in the production of bio-fertilizer), reduces the addition of methane to the atmosphere as these add methane to the atmosphere when left to decay on their own. Bio-fertilizer when compared to raw (undegraded) organic manure has the advantage of easier assimilation by plants and also the odor reduces after degradation (Swathi ,2010; Udemezue, Mmeremikwu, and Eluagu, 2021). The risk with raw organic manure is that it may contain pathogens such as Salmonella Spp. which may contaminate crops such as leafy vegetables and lead to the ingestion of the pathogen when the product is consumed. Bio-fertilizer also contains useful microorganisms which may not be present in organic (degraded) fertilizer(Khosro and Yousef,2012). These bio-fertilizers can be produced from cheap waste materials which are abundant in Nigeria and the cost of production is low compared to inorganic fertilizers which required high energy (Udemezue, Mmeremikwu, and Eluagu, 2021).

Constraints to adoption of bio-fertilizer among farmers

According to Udemezue, Mmeremikwu, and Eluagu(2021) ,some of the major constraints are as follows:

Lack of regulatory acts and facilities for testing the samples: Technical tests must be carried out to verify their safety at global scale. Current research of the use of biofertilizers in different regions of the world is necessary to obtain a framework that facilitates the development of future investigations in the agricultural sector and, consequently, promote the reduction of environmental impacts associated with the continuous use of chemical fertilization.

Reduction in the population of bacteria under certain climate conditions and influence of surrounding microflora and fauna: On application of bio-fertilizers to seeds, roots or soil, mobilizes the availability of nutrients through their biological activity and building up the microflorain particular and in turn the soil health in general. Their bio-efficacy is dependent on many biotic and abiotic factors of which unfavorable climate conditions such as changes in temperature and humidity can cause a decline in the bacterial populations.

Possible risks for the safety of consumers and the physicochemical and biological stability of soils: High contents of ammonia can burn the foliage and roots of plants; the presence of manure could increase the amount of weed flora. The presence of heavy metals such as mercury, chromium and lead brings a threat due to their carcinogenic potential and their capability of bio-accumulation and biomagnification in the food chain. Owing to this reason, the use of manure to fertilize soils should be well assessed.

Requirements for application: Extensive and long-term application may result in accumulation of salts, nutrients and heavy metals that could cause adverse effects on plant growth, development of soil organisms, water quality and human health. Excessive application can generate extreme levels of nitrogen, ammonia and salts that could lead to significant reduction of plant growth and problems for farmers and the soil.

Inadequate popularization of bio-fertilizers and low level of farmer acceptance: In spite of having various potential activities, bio-fertilizers have not yet gained popularity among farmers for proper adoption. There are a variety of factors affecting the adoption of bio-fertilizers by farmers. They are not aware of bio-fertilizers' usefulness in increasing crop yields sustainably. Their lack of awareness about the concentration, time and method of bio-fertilizer application; about the efficacy of bio-fertilizers compared to their familiarity with the use of conventional and tested inorganic fertilizers is a serious limitation of their widescale application. Knowing the different constraints faced by farmers in the use of bio-fertilizers, the extent of adoption of bio-fertilizers can be increased by tackling these issues and problems.

CONCLUSION

Persistence application of chemical fertilizers and pesticides has created dangerous and hazardous to human health. Based on this, attention is now moving from consuming food grown with chemical fertilizers to food grown with organic fertilizers because of the hazardous and harmful effects that these foods have in the body when consumed. Bio-fertilizers can help solve the problem of food need of the ever increasing global population. It is important to realize the importance of bio-fertilizers so as to apply it in modern agricultural practice to bring about poverty reduction and food security as well. Applications of bio-fertilizers contain beneficial microbes that promote to a large extent, crop productivity. These potential biological fertilizers play a key role in productivity and sustainability of soil and protect the environment as ecofriendly and cost effective inputs for the benefits of farmers. Using the biological and organic fertilizers, a low input system can help to achieve sustainability of farming. In view of the above,this paper analyzed the term "bio-fertilizer," Types of Bio-Fertilizers and their mode of work, Differences between Bio-Fertilizer and Organic Fertilizer, benefits of bio-fertilizer over chemical fertilizers and Constraints to adoption of bio-fertilizer among farmers.

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A Review of Soil Management for Optimum Kola Production in Nigeria

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ABSTRACT

Cola nitida is a commodity crop of economic importance at international market with great contribution to the GDP of producing countries. However, present global demand is in excess of production and studies to know the cause of the deficit is of great concern. Hence, the objective of this study was to identify and establish the importance of soil management with agronomic practices for optimum kola production in Nigeria. This investigation was carried out using secondary data from Journals and online documentations that were restricted to Nigeria since, Nigeria supplies over 50% of the world Kola nut produced. The study revealed that kola production is declining due to factors like poor soil management, old age of kola plantations, poor information dissemination on improved technologies and seedlings, lack of organized kola farmers' cooperative societies, non-vibrant Kola farmers' association and lack of good transportation system as being main issues. However, soil fertility and nutrient management was identified as one of the most essential factors that have direct impact on the yield and quality of Kola in Nigeria. The study concluded that, supplying the kola plants with the right kind and amount of nutrients was very germane to sustainable Kola production in Nigeria. Soil productivity enhancement through application of organic fertilizers/manures, inorganic fertilizers, liming and mulching were recommended for improvement of Kola production in Nigeria when the correct kola genotypes are planted.

Keyword: Economic growth, good agricultural practices, global market, kola farming, soil management

INTRODUCTION

Kola is a tropical tree crop with over 20 species, out of which, *Cola nitida* (Gbanja) and *Cola acumulata* (Abata) are the two main species cultivated in Nigeria and *Cola nitida* is the only kola of inter-regional and international trade. The consumption of *Cola acumulata* is greatly cherished by the Yoruba of south-west of Nigeria; the people of the northern and southeast Nigeria prefer the *Cola nitida* (Ojo and Ehinmowo, 2010). Pertinently, agriculture is the main occupation of the native Nigerians and its contribution to the national economy is noteworthy. In that despite the presence of oil, agriculture remains the main source of income for most Nigerians (FAO, 2020). Agriculture accounted for about 70 % of Nigeria GDP before the advent of petroleum, of which Kola nut export was a major contributor, representing about 70% of the world production. Presently, agriculture provides employment for about 35% of the populace (World Bank, 2020). Agricultural exportation monthly contribution to the foreign earnings on monthly basis improved greatly in between 2016 and 2020 with a value of N4.1billions in 2016 which rose to N25 billion by January 2017, while it was N289 billion from April 2019 – March 2020 (Ukpe, 2020), this contribution represents about 29.94% of Nigeria total GDP in the 3rd quarters of 2021 (Doris, 2022). Looking at the first 6 months of 2020 only, the value was N204.45 billion, which shows that productivity was increasing in the sector and it enables export growth. And presently, Nigeria exported agro-food items is valued at ₦162.27 billion as at 2nd quarters of 2021(NBS, 2021). The objective of this study was to identify and establish the importance of soil management with agronomic practices for optimum kola production in Nigeria.

Kola production in Nigeria

According to FAOSTAT (2015), Nigeria is the largest producer of kola nuts in the world with 132,000 metric tons (44.9% of total world production) followed by Cote D'Ivore, Cameroon, Ghana, and Sierra Leone with 82,000, 46,500, 24,000, and 8,645 metric tons respectively. According to Agbebaku et al., (2020), kola producing States in Nigeria includes Ogun, Edo, Imo, Oyo, Ebonyi, Ondo, Anambra, Osun, Kogi, Abia, Nasarawa, Niger, Ekiti, Akwa- Ibom, Delta, Cross River and Kwara states (Fig. 1). In the kola producing states, there are specialized markets for bulk kola nuts trade that are patronized by wholesale traders (middlemen) from long distance areas. The long distance traders earn the highest profits, since they are the merchants with market price monopoly. They dictate the selling prices because they have access to transport facilities and capital resources (Agbebaku et al., 2020). However, kola plantation cultivation in Nigeria is ecologically limited to the rainforest zones of the south and riverine areas as well as the fringe of the savanna region. Presently, Ogun state produces the largest amount of Kola nut in Nigeria, devoting about 65,000 hectares of land and producing over 80,000 MT of the crop in 2010/2011 (National Survey on Agricultural Exportable Commodities, 2013). Ndagi, *et al*. (2012) affirmed that there were large plantations of kola in Niger state. Nutritionally, Abolude (2004) reported proximate composition of *Cola nitida* nut as 2.3% moisture, 10.5% crude protein, 3.1% ash, 13.3% crude fat, 17.5% crude fiber, 5.3% total carbohydrate, with abundance of Na, Mg, K and P, 2.8% caffeine, 0.05% theobromine and low level of trace elements indicating that kola is of high nutritive value.

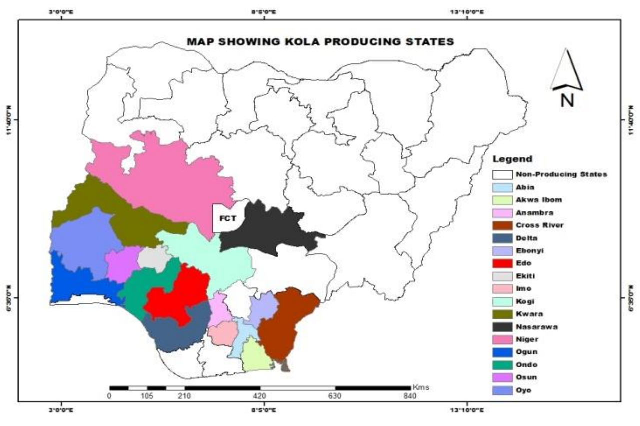

Figure 1: Map of Nigeria showing kola producing states
Source: Olasoji et al., 2022

Agro-ecological and soil conditions for Kola production

Kola trees can be found at altitudes of up to 300 meters (980 feet) above sea level, in areas with deep rich soils and evenly distributed rainfall. However, it can thrive well in sandy, loamy or clay soils but does best in well-drained soil (Health benefits times, 2020). To obtain optimum production and high quality kola produce, kola plantations should not be sited on land that is not suitable. Suitable land for Kola production should have soils that are deep and well-drained (Opeke, 2005). World Agroforestry Centre (2007) opined that kola needs a hot humid climate with mean annual temperature in the range of 26 -35°C, and a mean annual rainfall of 1,200–1,800 mm. Managing and sustaining optimum soil nutrient levels is the key to maintaining a continuous kola production. Fagbami and Ogunlade (2021) reported that soil suitable for the growth of kola varied and texturally ranged from loamy sand to clay loamy soils. It was opined that suitable soil for kola should have the physical and chemical properties in the range of 65-70% sand, 14-19% silt, 15-20% clay, pH 5-6, N 0.14- 0.18%, organic carbon 1.6-2.0% as well as Carbon/Nitrogen ratio of 11:13, available P (Bray 1) 6-8mg/kg and exchangeable cation of 0.35-0.40, 0.32-0.35, 2.9-3.5 and 0.9-1.0 cmol/kg for K, Na, Ca and Mg respectively.

Uses of kola nut

Kola is important economically to a significant proportion of Nigerians who are involved in its farming, trading, industrial processing and utilization (Ndagi, *et al*., 2012). The nut has great degree of importance to the tradition and culture of the three major Nigeria ethnic groups, the Hausa, Igbo and Yoruba (Ndagi, *et al*., 2012). The nuts are cherished in many cultural activities as a sign of friendship and peace, and are consumed during reunions, meetings, ceremonies and festivals (Asogwa, *et al.*, 2006). It is the only stimulant allowed and consumed by the various religious faithful.

Industially, kola nut contains caffeine and theobromine that makes it a useful stimulan t for the production of beverages and wine and soft drinks. They are good raw materials for pharmaceutical companies for their various products due to the alkaloids and other phyto-compounds contents (Opeke, 2005). Kola nut also has its useful application in the textile industry as they contains tannin useful in dye, while the pod husks are useful in compounding organic fertilizers, and feed for ruminants, the seed coats are used for monogastric animals feed formulation (Babatunde and Hamzat, 2005). It is used as digestive aid prior to meals to stimulate gastric juice and bile production (Obeng and Brown, 2001). On job security, Adejompo (2014) reported a significant positive impact of kola nut production on poverty alleviation, employment creation, industrial development and socio-cultural values in Nigeria. Medically, it is useful for treating diarrhea, toothache, headaches, exhaustion, hunger (caffeine content makes it an effective appetite suppressant), malaria, nausea, poison antidote, tonic and stimulant (Obeng and Brown, 2001).

Constraints to kola production

The demand for kola nut is in excess of production due to several limiting factors. Soil fertility degradation and management is one of the most serious threats to kola production resulting to poor seedling establishment, reduced growth and yield, poor quality nuts and increase pest infestations. According to Fagbami and Ogunlade, (2021), continuous soil nutrients mining through yearly kola pod harvests without replacement through fertilizer applications, usually leads to serious soil degradation. This with time leads to non-sustainable kola production. Fagbami and Ogunlade (2021) reported that the average quantity of N, P and K ha^{-1} per year removed through harvest under kola cultivated soil is 130.9kg N, 10.3kg P and 138.74kg K respectively. Hence, inadequate information on the soil and its fertility status has been recognized as a major challenge to kola production. Without due consideration for the quality of the soil, to ascertain its suitability or otherwise for kola cultivation is a great concern. The use of chemical fertilizer on kola plantation had been hindered by its scarcity, high cost, incomplete nutrient supply as well as possible enhancement of soil acidity (Egbe *et al.*, 1989). Also, to propagate kola seedlings using rich top soil have become difficult due to deforestation and erosion hazards.

Adebiyi, *et al.* (2011) had reported that low kola production and productivity was attributed to low adoption of good agronomic practices on kola farms. That farmer still plant nut from their old kola trees rather than purchasing improved kola seedlings from reputable sources like Cocoa Research Institute of Nigeria (CRIN), they have poor farm maintenance with regards to proper weed, pests and diseases controls of their plantations. Further reports showed that lack of information dissemination on improved technologies, attack of fruits by wild animals; water logging, unviable kola farmers' association and poor transportation system are other challenges facing kola production in Nigeria (Ndagi, *et al.*, 2012). On regional level, land tenure system was the main constraint to large scale kola production in the South East, coupled with the soils being heavily leached and highly nutrient deficient. Generally, the long gestation period of kola trees, sterility and susceptibility to epiphytes are very germane (Asogwa, *et al.*, 2012).

Soil Fertility Management

The soils of sub-Saharan Africa and Nigeria inclusive are poor in nutrients with low organic carbon (OC), clay contents, and exchange capacity (EC) hence presently, more than 70% of African soils are infertile and or degraded due to agricultural practices, human, and animal pressure (Bationo et al., 2006). Soil fertility depletion in smallholder farms is the important biophysical root cause of declining per capita food production hence, soil fertility replenishment is considered as an investment in natural resource capital (Sanchez, *et al*., 1997). Reports had showed that order of importance of essential nutrients for kola was boron>copper>zinc>phosphorus>calcium>potassium>magnesium. Fagbami and Ogunlade, (2021) reported that the effect of different rates and sources of boron on yield of kola showed that non boron deficient trees consistently gave higher yield (nearly thrice) than the trees with boron deficiency symptoms with a marked decline in yield while, the amount of nutrient (NPK) removed from the soil in harvested kola and found that the husk and the seed coat have higher content of N, P and K than the nut and suggested that the coat could be a good source of fertilizer. The calculated amount of N, P and K removed from the soil was estimated as 130.91kg, 10.34kg and 138.74 kg respectively hence, minimum NPK fertilizer recommended for kola production was put at 131kgN, 21kg P and 139kg K ha^{-1}.

For adequate nutrient replenishment to enhance nutrient status of existing kola plantations, Adediran, *et al.* (2005) stated that effective soil characterization and assessment is needed, while the use of improved fallows planting of leguminous cover crops, efficient use and management fertilizers, adoption of low input technology involving use of organic manures supplemented with inorganic fertilizers, alley farming and bio-fertilization among others. However, it is necessary to document the soil and fertilizer resources, provide guidelines for the soil fertility management for the crop, while periodical assessment of the soils be put in place for sustainable soil management.

CONCLUSION

Soil fertility management was identified to be one of the most essential factors with direct impact on the yield and quality of Kola. Hence, appropriate nutrient replenishing methods on the soils should be used for its proper management. This will aim to prevent soil fertility depletion and guide against soil degradation which are the root causes of decline in kola productivity. This will involve effective soil characterization and assessment, efficient fertilizer use, mulching, liming, minimum land tillage and use of right cover crop at juvenile stage of cultivation. Suitability assessment of proposed sites for kola cultivation should be carried out before establishing any new kola plantation. Government should be supportive to kola farmers and other stakeholders along the kola value chain by granting soft loans, while scientist and extension agents should create needed awareness on new agronomic practices and technologies for better productivity and utilization.

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Effect of poultry manure rates on the growth and yield of turmeric (*Curcuma longa* L.) in unwana south-eastern Nigeria

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ABSTRACT

The assessment of different rates of poultry manure on the growth and yield of turmeric (*Curcuma longa* L.) was conducted at the Teaching, Demonstration and Research (TDR) farm of the Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic, Unwana during the 2021 cropping season. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each replicate was made up of four (4) plots. The treatments include poultry manure at rates of 0, 4, 8 and 12 kg/bed. Evaluation on growth parameters were made at 4, 8, 12, 16, 20 and 24 weeks after planting (WAP) on plant height, number of leaves, leaf area, stem girth on each plot while yield parameters; number of rhizomes, weight, length and rhizome yield were determined at harvest. The analysis of variance (ANOVA) result shows that the application of poultry manure at 12 kg/bed significantly increased turmeric rhizome yield of 12.92 t/ha, weight 5.167 kg, length 8.97 cm, plant height, number of leaves, leaf area and stem girth. However, control plots consistently gave the least values on all the parameters assessed. Therefore, we recommend poultry manure application at 12 kg/bed for optimum production of turmeric in the study area.

Keywords: Application rates, Poultry manure, Turmeric, Yield

INTRODUCTION

Turmeric (*Curcuma longa* L.) belongs to family Zingiberaceae and is cultivated in about 19 States in Nigeria. It is a minor crop that plays significant role in the food chain supply in Nigeria (Olojede and Igbokwe, 2001). Nigeria plays a dominant role in turmeric production due to their favorable environmental condition. Turmeric serves as food colouring agent, useful in cosmetics and pharmaceuticals in treatment of various kinds of diseases (Semwal et al., 1997).

Considering the medicinal values of turmeric and the environmental problems caused by chemical fertilizer application, it is important to cultivate turmeric using organic manure (poultry manure). Poultry manure is regularly applied to many root crops for higher yield (Vanek, 2003). It supplies adequate organic matter in the soil with improvement in soil physical and chemical conditions and also enhance crop performance (Ano and Agwu, 2005). Ojeniyi (2000) reported that organic manure provides all the nutrients that are required by the plant, maintain the C:N ratio in the soil, thereby improves crop yield. Therefore, the objective of this study is to recommend the appropriate poultry manure rates required for the optimum production of turmeric in Unwana, South-eastern Nigeria.

Materials and Methods

The field experiment was conducted at the Teaching, Demonstration and Research (TDR) farm of the Department of Horticulture and Landscape Technology, Akanu Ibiam Federal Polytechnic, Unwana-Afikpo South Local Government Area in the South eastern part of Nigeria during 2021 cropping season. Unwana is located on the latitude 06^0 $05^'$N and longitude 08^o $03^'$E with an elevation of 300 m above sea level (NIMET, 2014). The climatic and vegetation types of the area are generally humid tropical rainforest with mean annual rainfall of about 3,500 m and mean daily temperature of 21^0C to 32^0C (Njoku et al., 2006). Before the commencement of the experiment, soil samples (0 to 20 cm depth) was randomly collected at the experimental site using soil auger at twelve (12) different points. The samples were bulked to produce composite samples which were air dried and sieved with 2 mm sieve. Also samples of poultry manure were subjected to chemical analysis.

The experimental site was cleared manually with cutlass and a raised bed of 2 x 2 m was made with hoe. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each replicate is made up of four (4) plots making a total of twelve (12) plots. The treatments comprised of poultry manure at the rate of 4, 8, 12 kg/bed and a control plot. Healthy turmeric rhizomes was obtained from National Root Crop Research Institute (NRCRI) Umudike, Abia State. The test crop was planted at a spacing of 50 cm x 45 cm. Decomposed poultry manure was applied two weeks after emergence at the rate of 0, 4, 8 and 12 kg/bed using band placement method. The site was weeded at interval of four weeks using cutlass and weeding hoe till harvesting period. Earthen up operation was done twenty four (24) weeks after planting (WAP).

Data were collected on plant height, number of leaves, leaf area, stem girth at 4, 8, 12, 16, 20 and 24 WAP while yield values; number of rhizomes, weight and length of rhizome were determined at harvest in each of the experimental plot. The data collected were subjected to analysis of variance (ANOVA) and the treatment means separated using Fishers Least Significant Difference at 5% level of probability as described by Obi (2012).

RESULTS

The result of the pre-planting chemical and physical properties of the soil in the experimental area is presented in Table 1. The pH was 5.80 which show that the soil slightly acidic. The soil is low in organic carbon and nitrogen. The soil of the site was classified as clay loam. The nutrient content of poultry manure is also presented in Table 1.

Table 1: Chemical Composition of Poultry Manure and Experimental plot

Elements	Poultry Manure Values	Experimental Plot
pH H_2O	7.62	5.80
Organic Carbon (g/kg)	28.22	14.30
Organic Matter (g/kg)	48.65	24.90
Nitrogen (g/kg)	4.50	1.50

Phosphorus (ppm)	2.86	7.80
Potassium (cmol/kg)	6.25	0.32
Magnesium (cmol/kg)	0.42	1.00
Calcium (cmol/kg)	5.20	3.00
Sodium (cmol/kg)	0.35	0.02
Sand	---	380
Silt	---	140
Clay	---	480

Plant Height (cm)

Poultry manure application significantly (P<0.01) increased the plant height from 4 to 24 weeks after planting (WAP) (Table 3). The taller plants (58.37cm) was obtained at 12 kg/bed manure rate at 24 WAP, followed by 8 kg/bed (50.57 cm). The plant height between 0, 4 and 8 kg/bed were statistically the same at 4, 8 and 24 WAP. Increasing poultry manure rates significantly (P<0.01) increased the plant height. The least values of plant height were consistently recorded at 0 kg/bed of manure rate.

Table 3: Plant Height (cm) of Turmeric (*Curcuma longa* L.) as affected by Poultry Manure Rates

Poultry Manure (kg)	4	8	12	16	20	24
0	8.43^{b}	12.67^{b}	17.47^{c}	24.10^{c}	31.67^{c}	42.67^{b}
4	10.67^{b}	14.33^{b}	22.43^{b}	29.00^{b}	37.00^{b}	45.3^{b}
8	11.00^{a}	16.67^{b}	23.90^{b}	29.87^{b}	38.23^{b}	50.57^{b}
12	17.33^{a}	22.50^{a}	31.10^{a}	37.80^{a}	45.83^{a}	58.37^{a}
F-LSD$_{0.05}$	3.109	5.009	4.787	5.100	5.276	6.485

Means in the same column having the same letters are not significantly (P<0.05) different using F-LSD N.S = Not Significant (P<0.05)

Number of Leaves

The difference in number of leaves per plant at 12 WAP was however not statistically significant (P<0.05). The highest number of leaves per plant of approximately 23 leaves was obtained at 12kg/bed manure rate at 24 WAP. The 0 kg/bed of manure consistently recorded the least number of leaves per plant (Table 4).

Table 4: Number of Leaves per Plant of Turmeric (*Curcuma longa* L.) as affected by Poultry Manure Rates

Poultry Manure (kg)	4	8	12	16	20	24
0	1.67^{b}	3.83^{b}	6.00^{a}	9.58^{b}	12.43^{c}	11.33^{b}
4	2.00^{b}	4.00^{b}	6.25^{a}	11.92^{b}	15.62^{b}	13.6^{b}
8	3.33^{b}	5.08^{a}	7.42^{a}	12.83^{b}	17.53^{b}	15.33^{b}
12	5.00^{a}	6.17^{a}	10.17^{a}	18.48^{a}	24.50^{a}	22.55^{a}
F-LSD$_{0.05}$	1.597	1.716	N.S	5.346	4.168	3.822

Means in the same column having the same letters are not significantly (P<0.05) different using F-LSD N.S = Not Significant (P<0.05)

Leaf Area (cm^2)

Increasing poultry manure rates significantly (P<0.05) increased the average leaf area per plant in turmeric from 12 WAP (Table 5). The highest leaf area per plant value of 138.3 cm^2 was obtained at 20 WAP using the poultry manure rate of 12 kg/bed. This is however, significantly (P<0.05) different from other leaf area per plant value obtained at 20 WAP. The 0 kg/bed poultry manure rate gave the lowest leaf area per plant, significantly (P<0.05) different from others throughout the period of the experiment from 12 WAP.

Table 5: Leaf Area (cm^2) of Turmeric (*Curcuma longa* L.) as affected by Poultry Manure Rates

Poultry Manure (kg)	4	8	12	16	20	24
0	7.50^a	21.80^a	37.70^b	43.80^b	43.00^b	36.20^c
4	4.60^a	17.40^a	74.20^b	86.00^b	86.50^b	87.70^b
8	2.80^a	46.50^a	65.10^b	79.30^b	81.80^b	85.80^b
12	2.90^a	46.60^a	123.70^a	132.90^a	138.30^a	123.30^a
FLSD$_{0.05}$	N.S	N.S	57.59	51.94	48.83	37.63

Means in the same column having the same letters are not significantly (P<0.05) different using F-LSD N.S = Not Significant (P<0.05)

Stem Girth (cm)

Poultry manure application significantly (P<0.05) increased the stem girth from 16WAP. The highest stem girth value of 2.53cm was obtained at 20WAP using poultry manure rate of 12kg/bed, followed by 2.52cm at 24WAP. Stem girth increased as poultry manure increased from control plots to 12kg/bed across the various weeks assessed. The 0kg/bed poultry manure consistently gave the least values across board (Table 6).

Table 6: Stem Girth (cm) of Turmeric (*Curcuma longa* L.) as affected by Poultry Manure Rates

Poultry manure (kg)	4	8	12	16	20	24
0	0.53^b	0.80^a	1.13^a	1.28^b	1.45^b	1.47^b
4	0.67^b	1.40^a	1.45^a	1.37^b	1.46^b	1.52^b
8	1.43^a	1.16^a	1.60^a	1.65^b	1.76^b	1.87^b
12	1.45^a	1.44^a	1.54^a	2.48^a	1.53^a	2.52^a
F-LSD$_{0.05}$	0.783	N.S	N.S	0.738	0.786	0.782

Means in the same column having the same letters are not significantly (P<0.05) different using F-LSD N.S = Not Significant (P<0.05)

Number of Rhizomes

The highest rate of poultry manure application had positive effect on number of rhizomes produced (Table 7). 12 kg/bed of poultry manure gave the highest number of rhizomes of 157 which differed significantly from other rates of poultry manure. Number of rhizomes increased as poultry manure rates increased from control plots to 12 kg/bed.

Weight of Rhizomes (kg)

The weight of turmeric that received poultry manure significantly (P<0.01) differed from the control. The harvested rhizomes with weight of 4.167 kg were recorded in plants treated with 12 kg/bed of poultry manure. Weight of rhizomes produced at 4 kg/bed (3.667 kg) and 8 kg/bed (4.167 kg) were statistically the same. The control plants without any manure (0kg/bed) gave the least weight of rhizomes 2.388kg significantly (P<0.05) different from the other (Table 7).

Length of Rhizomes (cm)

The 12 kg/bed of poultry manure produced the longest rhizomes of 8.97cm differed significantly from others (Table 7). Length of rhizomes produced at 4 kg/bed and 8 kg/bed of poultry manure of approximately 7cm and 8cm respectively were statistically the same. The control plots gave the least length of rhizomes of 5.43 cm.

Rhizome Yield (t/ha)

Increasing poultry manure rates in turmeric significantly (P<0.05) increased the rhizome yield (Table 7). Application of poultry manure produced the highest rhizome yield of 12.92 t/ha, significantly (P<0.01) different from all others. Rhizome yield produced from 4kg/bed (9.17 t/ha) and 8kg/bed (10.42 t/ha) were statistically the same. The 0 kg/bed gave the lowest rhizome yield of 7.08 t/ha (Table 7).

Table 7: Number of Rhizomes, Weights, Length and Rhizome Yield of Turmeric (*Curcuma longa* L.) as affected by Poultry Manure Rates

Poultry Manure (kg)	Number of Rhizomes	Weight of Rhizomes (kg)	Length of Rhizomes (cm)	Rhizome Yield (t/ha)
0	42.00^{d}	2.388^{c}	5.43^{c}	7.08^{c}
4	83.30^{c}	3.667^{b}	6.73^{b}	9.17^{b}
8	111.70^{b}	4.167^{b}	7.58^{b}	10.42^{b}
12	157.00^{a}	5.167^{a}	8.97^{a}	12.92^{a}
F-$LSD_{0.05}$	27.86	0.644	0.940	1.612

Means in the same column having the same letters are not significantly (P<0.05) different using F-LSD N.S = Not Significant (P<0.05

DISCUSSION

The results of chemical and physical properties of the experimental plots showed that the surface soils were slightly acidic with pH values of 5.80. This is in line with the report of Azu et al. (2017) who reported high acidity in most soils of Ebonyi State. According to Azu et al. (2018), the high concentration of oxides of iron and aluminum coupled with the presence of 1:2 clay minerals in the clay fraction of most hydromorphic soils of Ebonyi State is responsible for high exchangeable acidity and pH as observed in the study. Total nitrogen and available phosphorus were low and below the critical level of 0.15% and 12 mg/kg as proposed by Osodeke and Ubah (2005). The organic carbon and organic matter were low indicating low soil fertility. Generally, the basic cations except calcium were low which might be responsible for the high pH.

The significant increase in turmeric rhizomes, weight, length and rhizome yield and other parameters with an increase in poultry manure rates is in agreement with the report of Manhas and Gill (2007), who stated that application of farm yard manure (FYM) increased the growth, yield and quality of turmeric. The application of 12 kg/bed of poultry manure gave the highest yield of turmeric in the experiment. This is also in line with the work of Ibeawuchi et al. (2012), who reported that, the use of high poultry manure without mineral fertilizer gave highest yield in respect of crop growth and yield performance in Cassava, groundnut and sorghum intercrop. Monapatra and Das (2009) reported that organic manure improved soil productivity and fertility which in turns improved yield and quality of such long duration crop like turmeric.

CONCLUSION

Poultry manure showed great potential on the growth and yield enhancement of turmeric (*Curcuma longa* L.) and also improve soil nutrient status. The application of poultry manure at the rate of 12 kg/bed proved to be the optimal rate for maximum production of turmeric in Unwana and therefore recommended.

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Review Of Cocoa Soil Research Recommendations For Adoption To Enhance Production In Nigeria

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ABSTRACT

Cocoa is a major agricultural produce in Nigeria but decline soil fertility among many other factors has been reported to affect yield. This was confirmed by various research findings on physical and chemical properties which indicated that soils of the cocoa ecology were deficient in some nutrients as a result of continuous mining without replacement. Low cocoa output per hectare has been attributed to several factors while adequate soil nutrient amendment has been reported to mitigate effect of these factors with optimal cocoa yield and quality recorded. Inadequate adoption of several soil research recommendations on various nutrient amendments is evident in annual output decrease of cocoa beans and reduced foreign earning from agricultural produce for Nigeria. Lack of policy towards implementation of soil fertility management and high cost of fertilizer has made most farmers not to amend their depleted cocoa soil. However, formulation of policies to boost cocoa production by educating cocoa farmers on soil research findings and establishment of amendment programmes which adopt guided scientific recommendations will increase cocoa output and income generation from cocoa beans.

Keywords: Cocoa beans, soil amendment, policy, foreign earnings

INTRODUCTION

Cocoa, a leading agricultural produce is cultivated mainly in fourteen states of Nigeria known as the cocoa belt which comprise of states such as Abia, Akwa Ibom, Cross River, Delta, Edo, Ekiti, Ogun, Ondo, Osun, Oyo, Kogi, Kwara, Adamawa and Taraba (. The demand on climate, water as well as soil properties (Table 1) made it to adapt favourably to these areas measured by growth performance and yield. Cocoa beans (brown bean which is main commodity obtained from cocoa pod when fermented and dried) and it by-products have served as major source of foreign earnings for government, income for farmer and cocoa trader. It by-product also have been identified as raw material for industries and potential ingredient for several agro-inputs such as livestock feeds and fertilizer (Handojo, *et al.*, 2019**)**. However, Iremiren *et al.*, (2012) has observed that most cocoa plantations in Nigeria have experienced gradual decrease in yield and attributed this to poor soil management as well as late pod harvesting, lack of good agricultural practices, use of poor planting materials and age of the tree. To achieve better income when yield beginning to decrease, shifting cultivation has been the practice of early farmers but this is now impossible due to increase in population and land demand for various infrastructural facilities. Furthermore, It has been discovered that persistent low pod output in Nigeria is due to lack of readiness of farmer to rehabilitate their old cocoa trees because of high cost and difficulties always recorded in the process of establishing new cocoa farm. Many studies have shown that age of cocoa tree affect number of pod as well as beans per tree with recommendation that new tree be planted to replace the old ones (Mahrizal *et al.*, 2012; Gockowski *et al*., 2011). Pests and diseases have been reported as one other factor that is responsible for low cocoa production (ICCO, 2015). It has been confirmed that negative effect of pests and diseases lead to reduction in production through loss of cocoa pods and beans before harvest and during storage (Orisajo and Dongo, 2005). Moreover, there is a developed hypothesis that soil nutrients play major role in mitigating effect of these factors on yield of crop plant. Several cocoa soils have been researched on, with findings and recommendations available on nutrients management. Therefore to increase output in Nigeria, it becomes important to gather these findings for proper soil nutrient management targeted toward their adoption to enhance cocoa yield per tree per hectare. Results of physicochemical properties of cocoa soil in Ondo and Oyo state by Ogunlade *et al.*,2022, Cross river state by Ogunlade *et al.*,2012, Osun state Ogunlade *et al.*,2008 , eight states comprising Oyo, Kwara, Ogun, Ondo, Ekiti, Edo, Abia and Cross river by Ogunlade and Aipokpodion 2006, Abia, Cross River and Edo state by Agbeniyi *et al.*,2021, Kwara state by Ibiremo *et al.*, 2017 and Edo state by (Ipinmoroti and Ogeh 2012; Ogeh and Ipinmoroti 2013) as well as recommendations on cocoa soil in Nigeria were reviewed.

Research results on physiochemical properties of some cocoa soils

Results of soil physical and chemical properties (Table 3) and the critical values recommended for cocoa production (Table 2) indicated the textural classes of most cocoa soils to be sandy loam and loam soil with a range of 660-810% sand, 125-174% silt and54-200% clay. The silt + clay content ranged from 17.9-37.4% which showed that most cocoa soils are below ideal value of at least 32% silt + clay content recommended (Egbe *et al.*,1989). Halder (2013) emphasized on importance of soil texture and stated that it is a major factor that determined capacity to retain nutrient and water needed for plant growth. Soil organic carbon contents ranged from 0.096-29.90 g/kg for all state. The values were below 30.00g/kg recommended for cocoa production. The cocoa soil pH ranges of 4.43-6.67 were recorded, which showed slight acidity while Abia state with lowest value (4.43) indicated strong acidity. Snoeck (2016) like other studies has indicated soil pH as important factor that affect crop production and stated that soil chemical properties as well as plant nutrient uptake depend strongly on pH. Thus, it requires special management technique to obtain optimal productivity of cocoa. The report has shown that total N contents of cocoa soils ranged from 0.01 to 7.1%. The N content of Oyo state (Ibadan), Ondo state (Owena) and Edo state soils were below critical value of 0.9g/kg (Table 2) recommended for cocoa cultivation. Also, soils available P content ranged from 1.76-14.71mg/kg, which showed that Oyo state (Ibadan), Ondo state (Owena), Cross River state and Osun state soils were lower than 10.00mg/kg recommended for cocoa cultivation. Ogunlade and Aikpokpodion (2006) in their assessment of soils across cocoa ecologies of Nigeria reported that phosphorus is grossly inadequate for optimum cocoa yield. And this was supported by Aikpokpodion (2010) who reported that 6 to 8% of phosphorus has been loss through nutrient mining via pod harvest while some are washed away through rain water. The soils exchangeable K contents indicated a range of 0.07-0.83cmol/kg across the cocoa ecologies and most soils of the cocoa ecologies were below critical value of 0.30cmol/kg. Exchangeable Ca content was in the ranged of 0.76-28.44cmol/kg which showed that some of the soil were lower than critical value of 5.00cmol/kg. Cocoa soils Mg content of 0.56-4.65 cmol/kg showed that some soils were lower than 0.8cmol/kg which is the critical level for cocoa cultivation. Ipinmoroti *et al.,* (2009) confirmed low Mg content in some Cocoa plantations in Ibadan, south-western Nigeria and associated deficiency to high sand content, severe weathering, soil erosion and clay eluviation. The results of Mn content showed 2.94mg/kg value for Edo which is the lowest of all cocoa soils and indicated that values were above critical limit of 0.1mg/kg required for cocoa cultivation. Iron content was lowest in Ondo state (Owena) (25.70mg/kg) and highest in Edo state (124.00mg/kg). These values were higher than critical value of 4.5mg/kg required for cocoa cultivation. Copper content was lowest in Oyo state (0.74mg/kg) and indicated that some cocoa soils (e,g Ondo and Edo state) were below the critical limit of 2.5mg/kg required for cocoa cultivation. The Zinc content showed 0.56mg/kg value for Osun as the lowest of all cocoa soils which was higher than critical limit of 0.1mg/kg required for cocoa cultivation.

Research recommendations on cocoa soil amendment

Ogunlade *et al.,* (2004) reported that soil amended with neem leaves and fruits gave better cocoa seedling growth with highest P-uptake and recommended use of neem leaf as organic fertilizer in P deficient soil. Positive effect of cocoa pod husk (CPH) amendment on cocoa seedling growth was recorded and potential to increase nutrient uptake as well as serve as liming material was reported by Adejobi *et al.,* (2010) and recommended amendment of cocoa soil with 25tonnes per hectare CPH. Also, Ogunlade *et al.,* (2012) reported significant increase in cocoa yield with CPH compost and NPK fertilizer in the first year but observed significant yield increase in compost treated cocoa tree at the second year than others and therefore, recommended application of CPH for higher cocoa yield. Amendment with neem plant material fortified with CPH has been reported to supply basic cations, increase N and pH (Ogunlade *et al.,* 2008). Separate report from Adejobi, 2011 and Akanbi *et al.,* (2011) showed increase in the growth as well as nutrient uptake in cocoa seedlings when CPH was combined with organomineral fertilizer, and positive effect of oil palm bunch ash (OPA) on acidic soil respectively. These materials were recommended for use as sources of nutrients (N,P,K,Ca and Mg) and liming material. Also, Akanbi *et al.,* (2012) studied further on effect of CPH ash and OPA with and without NPK fertilizer and recommended the combine application of organic together with inorganic fertilizer to obtain better performance than sole applications of each in cocoa production. Ogunlade and Aipokpodion, (2006) reported negative effect of inadequate phosphorus on cocoa yield and recommended that farmer should be educated, encouraged and assisted to consider soil amendment materials for profitable production. Likewise, Iloyanomon (2008), reported long term benefit of 16kg P (37kg of P_2O_5) per hectare of Sokoto rock phosphate and recommended application for the adjustment of phosphate deficiency in soil. Also, Ogunlade *et al.,* (2005) recommended the application 10kgN per hectare to have a significant cocoa seedling growth in nitrogen deficient soil. Ipinmoroti et al., 2005 showed that organic materials (manure) were better sources of nutrients to plant with optimal nutrient released as well as increase in soil organic carbon content than inorganic fertilizers and this was confirmed by Ogunlade *et al.,* 2008 that observed no significant differences between the yield of cocoa tree amended with organic, organomineral as well as NPK fertilizer. Adejobi and Akanbi (2012) reported that cocoa seedling performance were enhanced by chemical and organic fertilizer treatments but recommended the use of organic materials as nutrient sources because of its promising effects on cocoa and soil. Likewise, Iloyanomom, (2008) reported that organic manure (CPH) served as alternative source of nutrient to cocoa tree and recommended it application in cocoa cultivation. Furthermore, Orisajo *et al.,*(2010) reported a significant increase in root mass of cocoa with poultry litter amendment and reduction of nematode number in the soil with 100% survival of cocoa seedling recorded 3months after transplanting to poultry litter amended plots on the field contrast to 35% dead in unamend plots and recommended cocoa soil amendment with poultry litter to have profitable field establishment.

Report of Ogbeide and Ibiremo (2021) showed that Cocoa Research Institute Nigeria in 1986 has recommended amendment of soil with 4g P/tree in the year of planting, 10g P/tree in the second and third year after planting and 11-23g P/tree for fourth and six-year old cocoa plantation when grown on land cleared from forest and NPK fertilizer practices of 10kgN+4kgP+4kgK/tree in the first year, 25gN+4gP +3gK/tree in second and third year after planting and 50-100g N+12g P+ 25gK/tree fourth and six-year of old cocoa plantation grown on land previously cropped with trees or arable crops. The increasing market for organic farm produce does not exclude cocoa beans and assessment of farmers' knowledge on organic cocoa production by Ogunlade *et al.*,(2022) showed that 61.1% of farmers did not know about organic cocoa and recommended proper education on need to make use of organic inputs (e.g organic fertilizers) toward improving quantity and quality of cocoa beans export. The evaluation of Nigeria land by Obatolu and Oduwole (2006) revealed that, it is highly suitable for cocoa production and they emphasized need to maximize this potential so as to increase production. Aipokpodion (2012), worked on remediation of heavy metal contaminated soil using Sokoto rock phosphate and found that available land suitable for cocoa cultivation and increase in output of existing plantation could be achieved through amendment of soil (contaminated) with Sokoto rock phosphate especially in the crude oil rich region and mining sites of the country.

Prospect of cocoa production through adoption of research findings

Nigeria has a high comparative advantage in the production of cocoa and therefore, it becomes necessary that government agencies educate farmers on the impact that adoption of cocoa soil research recommendations will have on cocoa performance. Specific policy programmes on soil fertility management to enhance national cocoa output and sustain continued supply of high quality and quantity cocoa bean to the world market should become government main target. The economic policy document by Federal Government of Nigeria to diversify economy with emphasises on the need to boost cocoa production should include soil management with focus on adoption of research findings and recommendations. High cost of procurement made most farmers not to use fertilizer (Asimiyu and Omonona 2013) and as such a subsidize fertilizer programmes by government for cocoa soil, geared toward increase output should be drawn up because cultivating cocoa on unfertile soil will among other factor leads to low productivity and poor returns (Asimiyu and Omonona 2013). Hence, establishing soil amendment programmes with view to adopt guided scientific recommendations will increase cocoa output and income generation from cocoa beans export which will contribute to the growth of Nigerian economy.

CONCLUSION

Deliberate Policies toward adoption of recommendations of cheap cocoa soil amendment research findings especially organic fertilizer production using materials such as cocoa pod husk, neem plant leave and Sokoto rock phosphate will increase cocoa output per hectare and reduce cost of production. Government policies should be targeted towards eliminating soil nutrient constrains to enhance cocoa yield and Nigeria foreign earning.

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Table 1: Optimal environmental and soil condition required for cocoa production

Factor	Temperature	Annual rainfall	Relative humidity	Altitude	Organic carbon	Soil depths	Acidity and alikanity
Value	18-21^{0}c to 31-32^{0}c	1200mm-3000mm	70%-100%	0 -900m	>30g/kg	>150cm	5.5 – 6.5

Source: FAO 1976; Egbe et al., 1989

Table 2: Optimal nutrient required for cocoa production

Nutrient	N	P	K	Ca	Mg	Mn	Fe	Cu	Zn
	g/kg	Mg/kg	←	cmol/kg	→	←	Mg/kg		→
Value	0.90	10.00	0.30	5.00	8.00	0.10	0.45	2.50	0.10

Egbe *et al.*,1989

Table 3: Soil physicochemical properties of some cocoa ecology in Nigeria

State	**pH**	**OC** g/kg	**N**	**Pm** g/kg	**K**	**Ca**	**Mg**	**Mn**	**Fe**	**Cu**	**Zn**	**Sand**	**Silt**	**Clay**	**Textural class**	**Source**
						cmol/kg			Mg/kg							
3 States (Abia, Cross river and Edo) 2021	4.43-6.22	1.60-3.80	0.13-0.36	1.33-14.72	0.18-0.40	7.95-28.44	1.39-2.18	4.27-10.90	1.00-4.16	0.32-2.09	0.44-2.72	715.2-795.2	125.6-205.6	79.2-139.2	Sandy loam	Agbeniyi et al., 2021 Hortson
Ranges for 3cocoa ecologies 2006	4.70-6.20	8.40-29.90	0.30-7.10	1.76-14.71	0.07-0.38	0.83-23.30	0.56-4.65	15.16-357.50	39.56-118.68	1.82-9.47	2.72-8.95	160-800	100-680	80-480	Sandy loam to Loam soil	Ogunlade and Aikpokpodion, 2006
Oyo (Ibadan) 2022	6.31	0.096	0.01	4.79	0.09	2.60	0.57	13.55	31.75	0.74	2.96	752	174	74	Sandy loam	Ogunlade et al., 2022
Ondo (Owena) 2022	6.54	0.109	0.01	5.40	0.28	2.35	0.65	35.60	25.70	1.08	2.43	812	134	54	Sandy loam	Ogunlade et al., 2022
Cross River 2012	6.20	8.10	1.80	6.20	0.24	6.92	1.30	80.30	108.40	5.20	10.40	660	140	200	Sandy loam	Ogunlade et al., 2012
Osun (Ikoromaja) 2008	5.80	13.50	1.80	4.6	0.15	2.42	0.56	71.80	64.50	8.81	0.56	640	160	200	Sandy loam	Ogunlade et al., 2008
Edo (Uhomora) 2012	5.70		0.40	10.40	0.12	7.30	2.10	2.94	124.00	1.38	32.40	810	125	65	Sandy loam	Ipinmoroti and Ogeh 2012, Ogeh and Ipinmoroti , 2013

Kwara 2017	6.3-7.3	5.3-22.8	0.36-2.17	2.5-8.8	0.14-0.83	0.76-5.11	0.60-2.20	-	-	-	-	504-802	92-311	81-336	Sandy loam to Loam soil	Ibiremo et al., 2017

Effect of liming on some soil quality parameters of brackish water fish ponds

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ABSTRACT

The effect of liming on some soil quality parameters of brackish water ponds of Nigerian Institute for Oceanography and Marine Research fish farm at Badore was investigated. Four ponds were selected for the study. Two ponds were limed with quick lime (calcium oxide) at the rate of 50kg/pond while the other two ponds were not limed. Selected soil quality parameters (pH, iron, magnesium, manganese, organic matter) were monitored during the dry season period which lasted from January to March 2019. Data obtained from the study indicated that pH of ponds ranged from 6.0 – 6.9 for the limed ponds and 4.0 – 5.2 for the unlimed ponds. Concentrations of iron ranged from 2.5 – 7.5mg/L for lime and unlime ponds respectively. Magnesium concentrations ranged from 5.0 – 80mg/L and 5.0 – 150mg/L for limed ponds and unlimed ponds respectively. Manganese concentrations ranged from 0 – 12mg/L and 5 – 12mg/L for limed ponds and unlimed ponds respectively. The organic matter content ranged for the soil from 5.1 – 5.4% for limed and 5.0 – 5.1% for the unlimed ponds. Liming and fertilization of pond soil could reduce soil acidity and invariably recondition of fish ponds and iron concentration of a pond.

Key words: Liming, soil quality, brackish water, fish ponds.

INTRODUCTION

The soil is a natural component of the environment that constitutes mineral matter, water, organic matter and living community that varies according to place and time (Sanhita *et al*, 2009 and

Fatima *et al*, 2012). Soil exert great influence on the environment and have an impact on the climatic conditions (Zornoza, 2015).

Soil quality is the continued capacity of soil to function as a vital living system within an ecosystem and land use boundaries, sustain biological productivity, and promote the quality of air and water environment and to maintain organism and human health (Doran and Safley, 1997). Changes in soil quality are not only associated with soil management, but also related to changes in temperature and precipitation (Andrews *et al*, 2004). Soil analysis is very essential to evaluate the quality of a particular ecosystem (Bhuyan and Islam, 2018, Islam *et al*, 2016, *Sharm et al*, 2014*).* Chemical properties like nutrient availability and soil pH affect the growth of organism in the pond (Jiao *et al,* 2009*).* Soil organic matter is the most important determinant of soil quality that is interlinked with soil pH (Brady and Weil, 1996).

Brackish water contributes to fish production in Nigeria (Dublin-Green *et al*, 2003.). The productivity of fish ponds in acid sulphate area is influenced by their state of reclamation, the treatment of the pond bottom with lime and fertilizer application. Growth of algae is observed when reclaimed acid sulphate soil limed with agricultural lime. Acidic bottom soil is a common problem in pond aquaculture, and fish farmers often apply agricultural limestone to ponds as a remedy. Aquaculture ponds are usually limed after draining for harvest and before refilling for the next crop (Boyd and Tucker, 1998).Proper reclamation and management of fish ponds in the soil can contribute to food production in Nigeria. The aim of this study is to determine the effect of liming on some soil quality parameters of brackish water fish ponds for the management control of soil acidity so as to improve fish growth rates and survival.

MATERIALS AND METHODS

The study was carried out at Nigerian Institute for Oceanography and Marine Research experimental fish farm Badore, Lagos. Four ponds namely Pond 5 (40.5m x 30.3m x 1.5), 6 (37.0m x 31.2m x 1.5m, 7 (35.5m x 28.5m x 1.5m) and 8 (38.5m x 28.5m x 1.5m) were selected for the study during the dry season from January – March, 2019. Ponds 5 and 6 were lime with quick lime (calcium oxide) at the rate of 50kg/pond while ponds 7 and 8 unlimed. The soil samples were collected from the pond bottom soil with the aid of soil auger. The soil samples collected were sun dried, grinded and sieved before analysis of pH and organic matter with the aid of Lamotte soil test kit. The concentration of manganese, magnesium and iron were analyzed using Atomic Absorption Spectrophotometer (AAS) (AAS – PG. AA500). The initial values of the soil quality parameter were taken and recorded before commencement of the liming.

The results obtained were subjected to analysis. Multiple variance of analysis (IBM SPSS Statistics 20). The analysis was carried out to test the significant difference between the four ponds bottom soil.

Table 1: Soil quality parameter of Badore fish farm before application of lime

Soil parameter	Pond 5	Pond 6	Pond 7	Pond 8
pH	4.8	4.9	4.2	4.8
Iron (mg/L)	2.7	2.8	2.7	7.0
Magnesium (mg/L)	5.0	5.0	20	5.0
Manganese (mg/L)	0.2	5.0	5.0	5.0
Organic matter (%)	5.0	5.0	5.0	5.0

Table 2: Mean soil quality parameter of Badore fish farm (dry season – January 2019

Soil parameter	Pond 5		Pond 6		Pond 7		Pond 8	
	Range	Mean ±SE	Range	Mean ±SE	Range	Mean ±SE	Range	Mean ±SE
pH	6.7 – 6.8	6.75±0.05 [c]	6.8 – 6.9	6.85±0.05 [c]	4.0 – 4.5	4.25±0.25 [a]	5.0 – 5.2	5.10±0.10 [b]
Iron (mg/L)	2.5 – 2.8	2.65±0.15 [a]	2.7 – 2.8	2.75±0.05 [a]	2.5 – 2.6	2.55±0.05 [a]	7.0 – 7.5	7.25±0.25 [b]
Magnesium (mg/L)	5.0 – 5.2	5.1±0.10 [a]	5.3 – 5.8	5.55±0.25 [a]	20 – 25	22.5±2.5 [b]	5.0 – 5.5	5.25±0.25 [a]
Manganese (mg/L)	0 – 1	0.5±0.5 [a]	5.0 – 5.2	5.1±0.1 [b]	5.1 – 5.3	5.2±0.1 [b]	5.0 – 5.1	5.05±0.05 [b]
Organic matter (%)	5.1 – 5.5	5.3±0.2 [a]	5.2 – 5.4	5.3±0.1 [a]	5.0 – 5.1	5.05±0.05 [a]	5.0 – 5.1	5.05±0.05 [a]

Means on the same row followed by the same letter are not significantly different at $P < 0.05$. SE = Standard error

Table 3: Mean soil quality parameter of Badore fish farm (dry season – February 2019

Soil parameter	Pond 5		Pond 6		Pond 7		Pond 8	
	Range	Mean ±SE	Range	Mean ±SE	Range	Mean ±SE	Range	Mean ±SE
pH	6.7 – 6.8	6.75±0.05 [b]	6.8 – 6.8	6.8±0 [b]	4.2 – 4.7	4.45±0.25 [a]	4.5 – 4.9	4.7±0.7 [a]
Iron (mg/L)	2.5 – 2.5	2.5±0 [a]	2.5 – 2.7	2.6±0.1 [a]	2.5 – 2.5	2.5±0 [a]	5.0 – 7.5	6.25±1.25 [b]
Magnesium (mg/L)	10 – 80	45±35 [a]	5 – 120	62.5±57.5 [a]	5.5 – 5.8	5.65±0.15 [a]	5.0 – 80	42.75±37.25 [a]
Manganese (mg/L)	5.0 – 5.2	5.1±0.1 [a]	5.0 – 5.1	5.05±0.05 [a]	5.0 – 5.3	5.15±0.15 [a]	5.0 – 5.2	5.1±0.1 [a]
Organic matter (%)	5.2 – 5.4	5.3±0.1 [a]	5.2 – 5.2	5.2±0 [a]	5.0 – 5.1	5.05±0.05 [a]	5.0 – 5.1	5.05±0.05 [a]

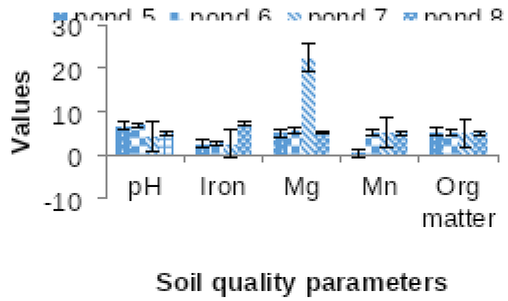
Means on the same row followed by the same letter are not significantly different at P < 0.05. SE = Standard error

Table 4: Mean soil quality parameter of Badore fish farm (dry season – March 2019

Soil parameter	Pond 5		Pond 6		Pond 7		Pond 8	
	Range	Mean ±SE	Range	Mean ±SE	Range	Mean ±SE	Range	Mean ±SE
pH	6.0 – 6.7	6.35±0.35 [b]	6.7 – 6.7	6.7±0 [b]	4.2 – 4.5	4.35±0.15 [a]	4.2 – 4.6	4.4±0.2 [a]
Iron (mg/L)	2.5 – 7.5	5.0±2.5 [a]	2.5 – 2.5	2.5±0 [a]	2.5 – 2.5	2.5±0 [a]	2.5 – 7.5	5.0±2.5 [a]
Magnesium (mg/L)	10.4 – 80	45.2±34.8 [a]	5 – 25	15.0±10.0 [a]	5.4 – 25	15.2±9.8 [a]	5.2 – 150	77.6±72.4 [a]

Manganese (mg/L)	5.1 – 12	8.55±0.15 [a]	5.0 – 12	8.50±3.5 [a]	5.5 – 12	8.75±3.25 [a]	5.2 – 12	8.6±3.4 [a]
Organic matter (%)	5.2 – 5.5	5.35±0.15 [a]	5.2 – 5.4	5.3±0.1 [a]	5.0 – 5.1	5.05±0.05 [a]	5.0 – 5.1	5.05±0.05 [a]

Means on the same row followed by the same letter are not significantly different at $P < 0.05$. SE = Standard error



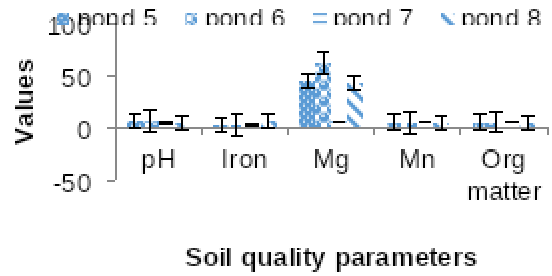


Figure 1: Mean soil quality parameters of four ponds observed in dry season (January 2019).

Figure 2: Mean soil quality parameters of four ponds observed in dry season (February,2019)

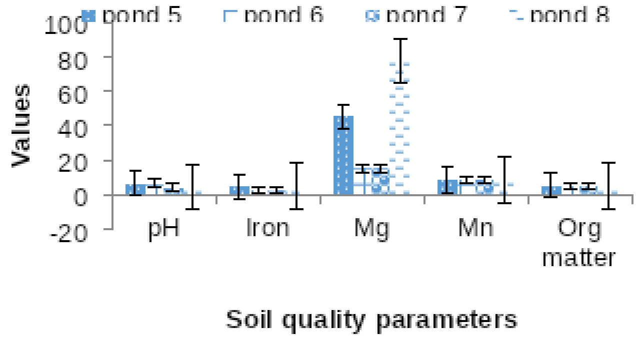


Figure 3: Mean soil quality parameters of four ponds observed in dry season (March, 2019)

RESULTS

The mean soil pH of ponds 5, 6, 7 and 8 were 6.75±0.05, 6.85±0.05, 4.25±0.25 and 5.10±0.10 respectively for the month of January during dry season. Pond 6 has the highest soil pH mean value of 6.85±0.05 while pond 7 has the lowest soil pH mean value of 4.25±0.25 in the month of January (Table 2 and figure 1). There were no significant differences ponds 5 and 6 at $P > 0.05$ but there were significant differences between ponds 7 and 8 at $P < 0.05$.

The mean soil concentrations of iron in the ponds 5, 6, 7 and 8 were 2.65±0.15, 2.75±0.05, 2.55±0.05 and 7.25mg/L respectively for the month of January during dry season. Pond 8 has the highest mean value of 7.25±0.25mg/L while pond 7 has the lowest mean value of 2.65±0mg/L in the month of January (Table 2 and figure 1). There were no significant differences between ponds 5, 6 and 7 respectively at $P > 0.05$. But there were significant differences between pond 8 and other three ponds at $P < 0.05$.

The mean soil concentrations of magnesium in the ponds 5, 6, 7 and 8 were 5.10±0.10, 5.55±0.25, 22.5±2.5 and 5.25±0.25mg/L respectively for the month of January during dry season. Pond 7 has the highest mean value of 22.5±2.5mg/L while pond 5 has the lowest mean value of 5.10±0.10mg/L (Table 2 and figure 1). There were no significant differences between ponds 5, 6 and 8 at $P > 0.05$. But there were significant differences between pond 7 and other three ponds sampled at $P < 0.05$.

The mean soil concentrations of manganese were 0.5±0.5, 5.1±0.1, 5.2±0.1 and 5.05±0.05mg/L for ponds 5, 6, 7 and 8 respectively for the month of January during dry season. Pond 7 has the highest mean value of 5.2±0.1mg/L while pond 5 has the lowest mean value of 0.5±0.5mg/L (Table 2 and figure 1). There were no significant differences between ponds 6, 7 and 8 at $P > 0.05$. But there were significant differences between pond 5 and other three ponds sampled at $P < 0.05$.

Mean soil of organic matter were 5.3±0.2, 5.3±0.1, 5.05±0.05 and 5.05±0.05% for ponds 5, 6, 7 and 8 respectively for the month of January during dry season. Ponds 5 and 6 have the highest mean value soil organic matter of 5.3±0.2% and 5.3±0.1% respectively. The lowest soil organic matter mean value was 5.05±0.1% for ponds 7 and 8 respectively (Table 2 and figure 1). There were no significant differences in all the ponds at $P > 0.05$.

Mean soil pH of ponds 5, 6, 7 and 8 were 6.75±0.05, 6.80±0, 4.45±0.25 and 4.7±0.7 respectively for the month of February during dry season. Pond 6 has the highest soil pH mean value of 6.8±0 while pond 7 has the lowest soil pH mean value of 4.45±0.25 in the month of February (Table 3 and figure 2). There were no significant differences ponds 5 and 6 at $P > 0.05$ also there were no significant differences between ponds 7 and 8 at $P > 0.05$.

Mean soil concentrations of iron in the ponds 5, 6, 7 and 8 were 2.5±0, 2.60±0.1, 2.5±0 and 6.25±1.25mg/L respectively for the month of February during dry season. Pond 8 has the highest soil iron concentration mean value of 6.25±1.25mg/L while ponds 5 and 7 have the lowest soil iron concentration mean value of 2.5±0mg/L in the month of February (Table 3 and figure 2). There were no significant differences between ponds 5, 6 and 7 respectively at $P > 0.05$. But there were significant differences between pond 8 and other three ponds at $P < 0.05$.

The mean soil concentrations of magnesium in the ponds 5, 6, 7 and 8 were 45±35, 62.5±57.5, 5.65±0.15 and 42.75±37.25mg/L respectively for the month of February during dry season. Pond 6 has the highest mean value soil magnesium concentration of 62.5±57.5mg/L while pond 7 has the lowest mean value soil magnesium concentration of 5.65±0.15mg/L (Table 3 and figure 2). There were no significant differences in all the ponds at $P > 0.05$.

Mean soil concentrations of manganese were 0.5±0.5, 5.1±0.1, 5.2±0.1 and 5.05±0.05mg/L for ponds 5, 6, 7 and 8 respectively for the month of February during dry season. Pond 7 has the highest mean value soil manganese concentration of 5.2±0.1mg/L while pond 5 has the lowest mean value manganese concentration of 0.5±0.5mg/L (Table 3 and figure 2). There were no significant differences between ponds 6, 7 and 8 at $P > 0.05$. But there were significant differences between pond 5 and other three ponds at $P < 0.05$.

Mean soil of organic matter were 5.3±0.2, 5.3±0.1, 5.05±0.05 and 5.05±0.05% for ponds 5, 6, 7 and 8 respectively for the month of February during dry season. Ponds 5 and 6 have the highest mean value soil organic matter of 5.3±0.2% and 5.3±0.1% respectively. The lowest soil organic matter mean value was 5.05±0.1% for ponds 7 and 8 respectively (Table 3 and figure 2). There were no significant differences in all the ponds at $P > 0.05$.

Mean soil pH of ponds 5, 6, 7 and 8 were 6.35±0.35, 6.70±0, 4.35±0.15 and 4.4±0.2 respectively for the month of March during dry season. Pond 6 has the highest soil pH mean value of 6.7±0 while pond 7 has the lowest soil pH mean value of 4.35±0.15 in the month of March (Table 4 and figure 3). There were no significant differences between ponds 5 and 6 at $P > 0.05$ also there were no significant differences between ponds 7 and 8 at $P > 0.05$.

Mean soil concentrations of iron in the ponds 5, 6, 7 and 8 were 5.0±2.5, 2.50±0.0, 2.5±0 and .2.5±0mg/L respectively for the month of March during dry season. Pond 5 has the highest soil iron concentration mean value of 5.0±2.5mg/L while ponds 6, 7 and 8 have the lowest soil iron concentration mean value of 2.5±0mg/L in the month of March (Table 4 and figure 3). There were no significant differences between ponds 6, 7 and 8 respectively at $P > 0.05$. But there were significant differences between pond 5 and other three ponds at $P < 0.05$.

The mean soil concentrations of magnesium in the ponds 5, 6, 7 and 8 were 45.2±34.8, 15.0±10.0, 15.2±9.8 and 77.6±72.4mg/L respectively for the month of March during dry season. Pond 8 has the highest mean value soil magnesium concentration of 77.6±72.4mg/L while pond 6 has the lowest mean value soil magnesium concentration of 15.0±10.0mg/L (Table 4 and figure 3). There were no significant differences in all the ponds at $P > 0.05$.

Mean soil concentrations of manganese were 8.55±0.15, 8.50±3.5, 8.75±3.25 and 8.6±3.4mg/L for ponds 5, 6, 7 and 8 respectively for the month of March during dry season. Pond 7 has the highest mean value soil manganese concentration of 8.75±3.25mg/L while pond 5 has the lowest mean value manganese concentration of 8.55±0.15mg/L (Table 4 and figure 3). There were no significant differences in all the ponds at $P > 0.05$.

Mean soil of organic matter were 5.35±0.15, 5.3±0.1, 5.05±0.05 and 5.05±0.05% for ponds 5, 6, 7 and 8 respectively for the month of March during dry season. Ponds 5 have the highest mean value soil organic matter of 5.35±0.15% while pond 7 and 8 lowest soil organic matter mean value was 5.05±0.05% (Table 4 and figure 3). There were no significant differences in all the ponds at $P > 0.05$.

DISCUSSION

pH of the soil ranged from 6.0 – 6.9 and 4.0 – 5.2 for lime and unlime ponds respectively during dry season (Table 2 – 4 and figure 1 – 3)). Susheela *et al*, (2014) observed pH of soil ranged from 6.9 – 8.9 during dry season.

The concentrations of iron in the bottom soil ranged from 6.0 – 6.9mg/L and 4.0 – 5.2mg/L for

Lime and unlime ponds during dry season (Table 2 – 4 and figure 1 – 3). Singh and Poernomo, (1984) reported iron concentrations levels of 3,321 and 3,378mg/L for unlime ponds, 3,140 and 1,867mg/L for lime ponds. Also Prihutomo *et al*, (2016) obtained iron concentrations levels for bottom soil of 50,400, 50,520, 56,060, and 50,220mg/L.

In this study concentration of magnesium in the bottom soil ranged from 5.0 – 150mg/L for lime and unlimes ponds during dry season (Table 2 – 4 and figure 1 – 3). The concentrations of magnesium in the bottom soil in this study were higher than (0.75 – 1.01mg/L) during dry season by Fatunbarin and Olojugba, (2014)

Concentrations of manganese in the bottom soil ranged from 0 – 25mg/L and 5.0 – 12mg/L for lime and unlime ponds respectively during dry season (Table 2 – 4 and figure 1 – 3). The values of manganese obtained in this study were lower than 18mg/L and 16mg/L for lime and unlime ponds respectively observed by Singh, (1985).

Organic matter obtained in this study ranged from 5.1 – 5.5% for lime ponds during dry season. The organic matter for unlime ponds ranged from 5.0 – 5.2% during dry season. The results obtained in this study were slightly similar to percentage organic matter (2.18 – 5.77%) observed by Rafiqul Islam *et al*, (2017) during dry season. In this study the pH of lime ponds were higher than unlime ponds. The higher the organic matter content, the more the lime required for a given change in the sediment pH (Barna and Zamal, 2011).

CONCLUSION

Liming of pond soil and fertilization could reclaim ponds thereby reconditioning deficiency of phosphate, low pH, and toxicity of aluminium, iron and manganese. Regular monitoring of water quality parameters is essential especially pH. If the ponds becomes acidic (below tolerance limit), a moderate and low rate application of powdered agriculture lime could be broadcast on the pond water in order to buffer the low pH and subdue the concentration of aluminium and iron. This would also reduce fixation of phosphate into acid sulphate bottom soil.

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Influence Of Rainfall Distribution On Palm Yield In Selected Areas Of Akwa Ibom State, Nigeria

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ABSTRACT

Rainfall is one of the determining factors in crop growth and development. The study examined the influence of rainfall distribution in the yield of oil palm in selected areas of Akwa Ibom state. The study was conducted in coastal areas (Eket and Oron) and upland areas (Uyo and Ikot Ekpene) Daily rainfall data were obtained from Nigeria Meteorological Agency (NiMet) and oil yield data were obtained from Akwa Ibom Ministry of Agriculture Uyo, for a period of 30 years (1989 – 2018) respectively. Descriptive statistics was used to determine the decadal rainfall amount and time series in was used to determine the relationship between rainfall and yield of oil palm. The result shows that upland upland areas witnessed increase in oil palm yield decade by decade whilst the yield of oil palm in coast areas continue to decline decade by decade. The upland areas of Ikot Ekpene and Uyo recorded increase of oil palm yield at the third decade with 14.40 mt/ha and 18.54 mt/ha respectively. Furthermore, all areas also witnessed increase in rainfall decade by decade with the coastal areas of Eket and Oron recording the highest at the third decade with 3765.40 mm and 3500.34 mm respectively. Also, the relationship shows decrease in yield of oil palm in Eket at $R^{2\,=}$ 0.1085 and $y = -0.0961x + 9.482$, Oron – $R^2 = 0.4226$ and $y = -0.0583x + 6.8127$; while yield of oil palm increase in Uyo at $R^2 = 0.2143$ and $y = 0.127x + 5.0344$, Ikot Ekpene – $R^2 = 0.3338$ and $y = 0.1583x + 4.9077$. This shows that sustainable production of oil palm could be achieves in upland areas under good management practices since the rainfall distribution the areas march with the crop water requirement.

Key words: Rainfall, Oil palm, crop production, coastal area, upland areas

1.0 INTRODUCTION

Oil palm (*Elaeis guineensis*) is as old as creation (Ndon 2006). All aspects of the tree are useful economically and for domestic purposes. It is commonly stated that oil palm originated in tropical rainforest area of West Africa (FAO, 2010). The fundamental belt goes through the southern scopes of Cameroon, Côte d'Ivoire, Ghana, Liberia, Nigeria, Sierra Leone, Togo and into Equatorial region of Angola and Congo (FAO, 2010; Ndon 2006). Processing of oil palm edible oil has been practiced in Africa for a large number of year and oil produced is profoundly hued and seasoned. It is a basic ingredient in a greater part of the conventional West African food. The traditional process is simple but tedious. Mature palms are single–stemmed and develop to 20 m tall. The leaves are pinnate and reach between 3 – 5 m long (Kei *et al.*, 1997). Three varieties of oil palm are accessible in Nigeria; specifically, Dura, Pisifera and Tenera (Nigerian Institute for oil Palm Research (NIFOR), 2009). The preferred variety among palm oil farmers in Nigeria is the half-breed Tenera, which is a crossbreed of the Dura (female) and the Pisifera (male). Tenera seedlings are produce by NIFOR and normally alluded to as extension work seeds (Thompson, 2010). Regarding examination, product of Tenera variety contains 25% oil by weight and Dura variety 18%. Therefore, a similar measure of Tenera can yield 30% more oil than the comparable product of Dura (NIFOR, 2010). Oil palm is likewise a basic food items. Around 90 percent of palm oil produced end in food products, while 10 percent is utilized in industries (Nwauwa, 2011).

Moreover, consistent soil moisture accessibility supports lively development and expanded yield of oil palm. Sufficient rainfall, good soil depth and water holding capacity add to water accessibility. In oil palm, as water insufficiency builds, stomata will stay shut and advancement and opening of spear will be repressed (Ndon, 2006). Water insufficiency antagonistically influences bloom inception, sex separation and hence brings about low sex proportion because of creation of more male inflorescences. Oil palm needs high measure of water to meet its monthly evapotranspiration needs (Udoh *et al.*, 2005). In regions, where lasting water source is accessible, basin irrigation system is conceivable. Where landscape is undulating and water is scanty during dry season, drip irrigation system is prescribed to keep four drippers for every palm in the weeded palm cycle to supply at least 90 liters of water for each palm every day during summer months, which will differ as per the evapotranspiration esteems in an area (Koh and Wilcove, 2007).

Temperature can be a restricting component for oil palm production. Best oil palm yields are acquired in places where a greatest normal temperature of 29 – 33^{o}C and least normal temperature of 22 – 24^{o}C are accessible (NIFOR, 2010). Higher diurnal temperature variation causes botanical fetus removal in districts with a dry season. The plant requires 1800 – 2000 daylight hours every year, consistent daylight of at least 5 hours of the day for better oil palm yield. Moist, deep and well-drained medium textured soils rich in humus content are viewed as ideal. Gravel and sandy soils, especially the coastal sands are not ideal for oil palm development (NIFOR, 2009). Heavy clay soils with helpless seepage properties may present issues of air circulation during rainy seasons (Basiron, 2007). Oil palm cultivation is vulnerable to the effect of climate change. It required average annual rainfall of 2000 – 2800mm (FAO, 2010). Rainfall patterns have an impact on the growth and development of palm trees, which has an impact on the output of oil palm. In addition to harming fresh fruit bunches (FFB), excessive rain also lowers the quality of plantation roads and paths, stifles harvesting, and results in flooding. Because of the length of the annual dry season, it affects oil palm productivity (Rizal *et al.*, 2008). The availability of soil moisture, which is influenced by the amount of rainfall received and, in certain circumstances, irrigation, is by far the most important factor in influencing the FFB yield of oil palm (Paterson, 2020b). Lack of moisture in an oil palm plantation slows growth, lowers yield production, and increase the risk of fire. The threat of floods and drought is anticipated to increase dramatically in the twenty-first century as a result of the effects of climate change (Ahemd *et al.*, 2021).

The cultivation of oil palm in Akwa Ibom State may be under great risk from the effects of floods in the coastal areas of the state. The capacity to produce palm oil is reduced in the areas of production within the state. Over the coming decades, Akwa Ibom State may witness frequent and severe floods due to the its proximity to water bodies. The harvesting of FFB is hampered or delayed by heavy rain brought on by a La Nina event, which also lowers the quality of crude palm oil (CPO) and results in rotten FFB and waterlogging (Paterson, 2020a). Long-term climate changes will affect Nigeria and other oil palm-producing countries. According to climate change estimates, the cultivation of oil palm will be hugely affected by climate change, with significant effects for the economy of rural dwellers, as well as the palm oil industries. Therefore, the aim of this study was to assess the influence of rainfall on the yield of oil palm in selected areas of Akwa Ibom State.

2.0 MATERIALS AND METHODS

2.1 Description of study area

The study was carried out in the coastal and upland areas of Akwa Ibom State. Four local government area were selected (figure 1) i.e., coastal area (Eket and Oron) and upland areas (Uyo and Ikot Ekpene). Akwa Ibom State lies between longitudes $7^{0}25'$ and $8^{0}25'$E and latitudes $4^{0}32'$ and $5^{0}30'$N. It has a humid tropical climate, characterized by distinct wet and dry seasons. Annual rainfall varies from 3,000 mm along the coast to 2,250 mm in the northern fringe, with 10 – 11 months of rainfall in the coastal and upland areas respectively. Temperature values are relatively high in Akwa Ibom State throughout the year with mean annual values varying between 26 and 28°C. Moreover, relative humidity remains at average of 70 – 80 percent throughout the year. Average sunshine circulates to 1,450 hours per year and the annual evaporation rate range from 1,500 – 1800 mm (Ekpeyong, 2013).

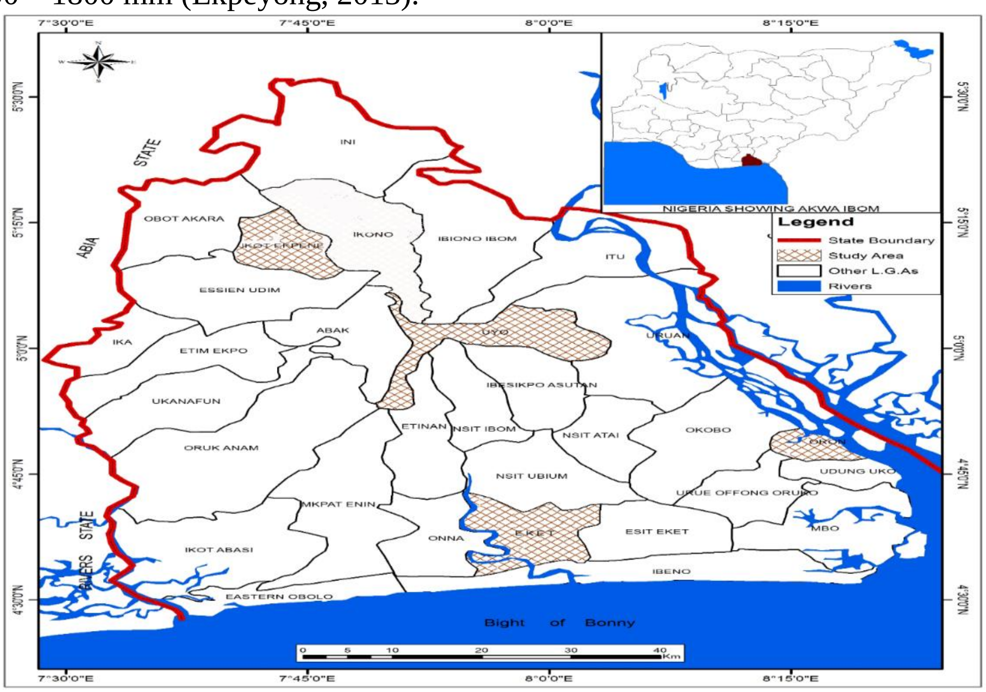

Fig. 1 Akwa Ibom State showing the study locations

2.2 Data collection

Daily rainfall data for coastal area (Eket and Oron) and upland area (Uyo and Ikot Ekpene were obtained from Nigeria Meteorological Agency, Abuja, for a period of 30 years (1988 - 2018).

Table 1. Geographical characteristics of the weather stations

Location	Latitude	Longitude	Elevation (m)
Eket	04°38'47.43"N	07°58'00.20"E	17.67
Oron	04°48'27.24"N	08°15'00.52"E	30.16
Uyo	05°30'45.36"N	07°55'56.16"E	54.23
Ikot Ekpene	05°11'22.39"N	07°42'55.40"E	70.10

Source: NiMet, 2018

2.3 Statistical Analysis

Descriptive statistics was used in determining the decadal rainfall amount and time series in was used to determine the relationship between rainfall and yield of oil palm.

3.0 RESULT AND DISCUSSIONS

3.1 Decadal rainfall and oil palm yield in coastal and upland areas of Akwa Ibom State (1989 – 2018)

The result in figure 2 and 3 shows average annual decadal rainfall and yield of oil palm respectively. The decadal rainfall in Eket, Oron, Uyo and Ikot Ekpene shows that first decade recorded 2943.65 mm, 2830.48 mm, 2093.53 mm and 1752.52 mm respectively; second decade recorded 3138.46 mm, 2953.74 mm, 2166.85 mm and 1853 mm respectively; and third decade recorded 3765.40 mm, 3500.34 mm, 2416.88 mm respectively. The highest amount of rainfall was recorded in the third decade with Oron recording 3765.40 mm, while the least amount of rainfall was recorded in the first decade i.e. Ikot Ekpene with 2943.65 mm. Furthermore, the decadal yield of oil palm for Eket, Oron, Uyo and Ikot Ekpene show that the first decade recorded 8.42 mt/ha, 8.82 mt/ha, 12.62 mt/ha and 12.45 mt/ha respectively; second decade recorded 7.99 mt/ha, 7.27 mt/ha, 15.52 mt/ha and 12.45 mt/ha respectively; and third decade 6.29 mt/ha, 5.34 mt/ha, 18.54 mt/ha and 14.40 mt/ha. Meanwhile, the highest amount of oil palm yield was recorded in the third decade with Uyo recording 18.54 mt/ha, whist the least amount of oil palm was recorded in the third decade with Oron recording 5.34 mt/ha. The result revealed that the increase in the amount of rainfall in the coastal areas results in the decrease in the yield of oil palm and versa.

According to Inter-governmental panel on climate change (IPCC), 2011, the amount of rainfall in coastal areas and others wet tropical zones of the world will continue to increase due to its proximity to water bodies resulting from climate change. Ahmed *et al.*, 2021, also reported an increase in oil palm yield in areas where the amount of rainfall is sufficient for its growth and development.

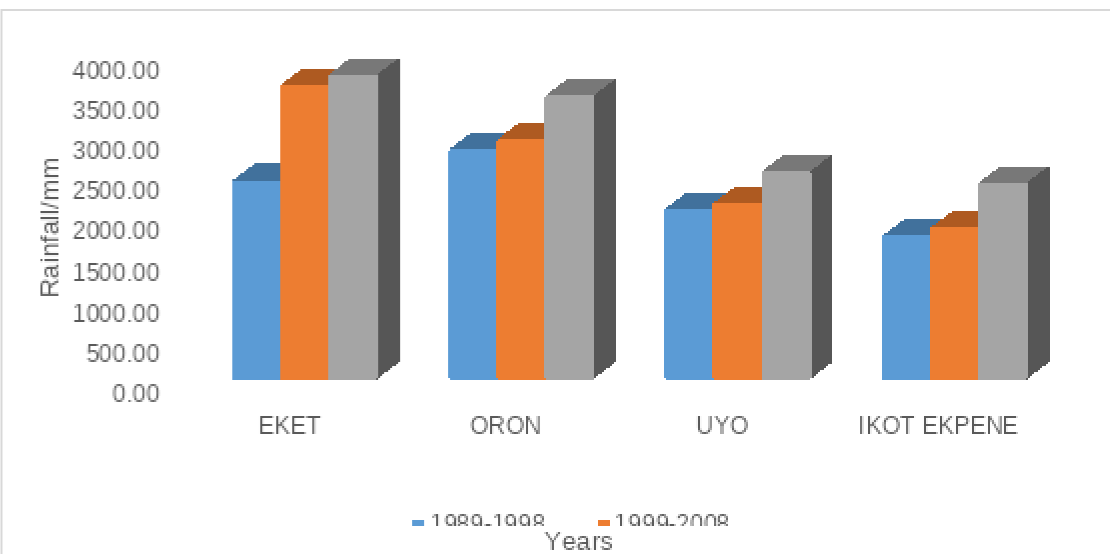

Fig.2: Average Annual decadal rainfall for Eket, Oron, Uyo and Ikot Ekpene (1989 -2018)

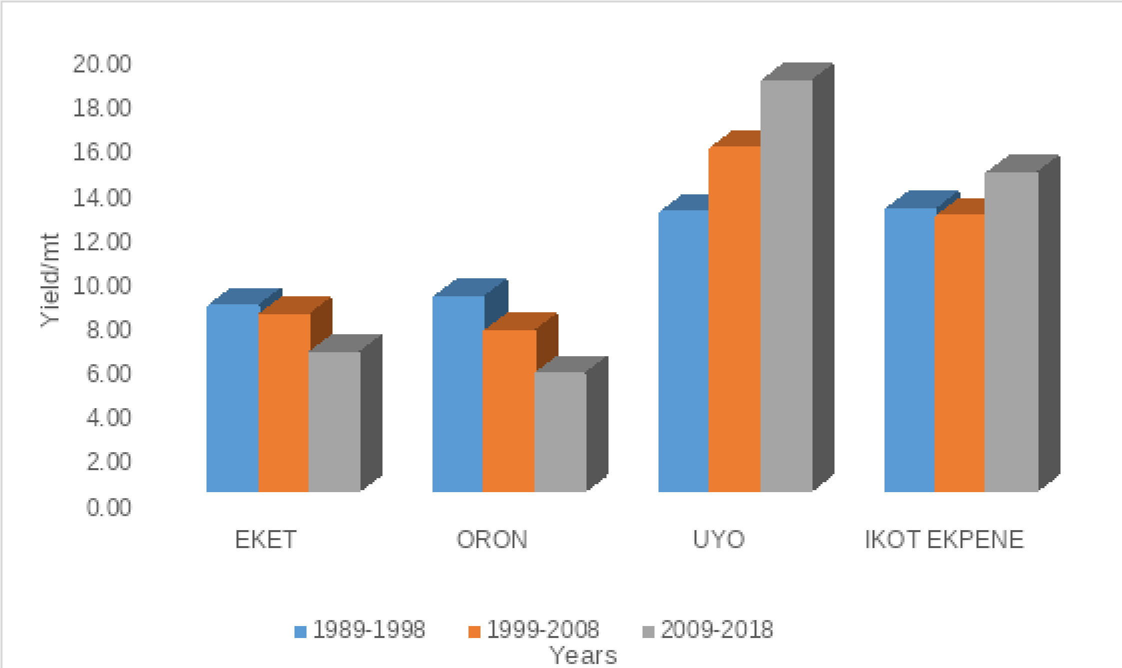

Fig.3: Average Annual decadal yield of Oil palm for Eket, Oron, Uyo and Ikot Ekpene (1989 - 2018)

3.2 Relationship between rainfall and yield of oil palm in coastal and upland areas of Akwa Ibom State (1989 – 2018)

Figures 3 – 7 show the trends of rainfall and yield of oil palm. The trend indicates decrease in yield of oil palm in Eket at $R^{2} =$ 0.1085 and $y = -0.0961x + 9.482$, Oron – $R^2 = 0.4226$ and $y = -0.0583x + 6.8127$; while yield of oil palm increase in Uyo at $R^2 = 0.2143$ and $y = 0.127x + 5.0344$, Ikot Ekpene – $R^2 = 0.3338$ and $y = 0.1583x + 4.9077$. The average yield recorded in Eket, Oron, Uyo and Ikot Ekpene were 7.95. mt/ha, 6.89 mt/ha, 15.22 mt/ha and 12.10 mt/ha respectively. The result shows that only Uyo and Ikot Ekpene recorded the yield that fall within the potential yields of 12 mt/ha and above predicted by NIFOR (2010) for rainforest agro-ecological zone of Nigeria; under condition of adequate nutrients, rainfall and other climatic variables, as well as good varieties. The decrease in oil palm yield in Eket and Oron may be attributed to increase in annual rainfall more than its requirement. Increase in yield of oil palm in Uyo and Ikot Ekpene may be due to increased average annual rainfall (i.e. average rainfall recorded in Eket, Oron, Uyo and Ikot Ekpene are 3822.50 mm, 3094.84 mm, 2272.24 mm and 2007.49 mm respectively). Oil palm is a tree crop that require annual rainfall of 2,000 – 2,800 mm for its optimal performance (Bello *et al.*, 2015). Ndon (2006) reported that oil palm and other tree crops has the capacity to tolerate high amount of rainfall more than the short duration crops (like maize, wheat, tomato, melon, sorghum, etc.) and tuber crops, since these are perennial crops and have medium potential for storing excess water (i.e. large body size, leaves, etc.) but not beyond its requirement.

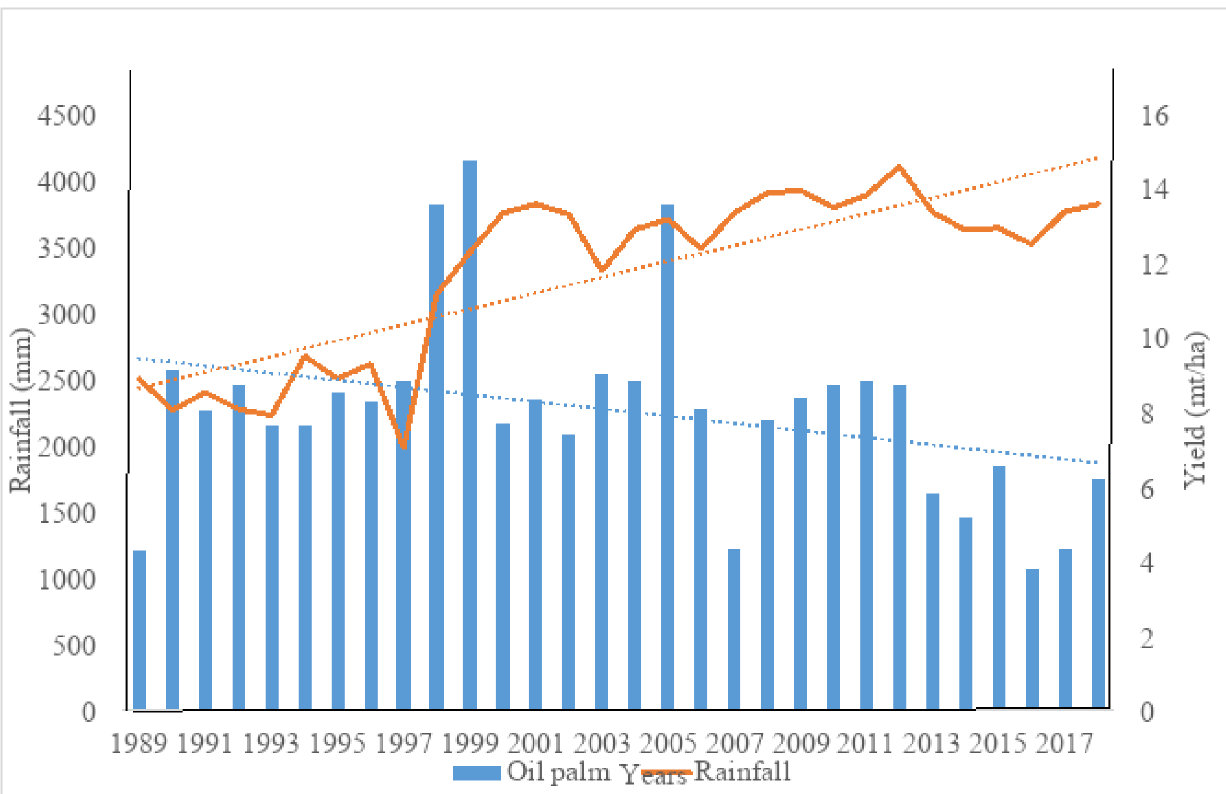

Fig. 4: Trend of rainfall and oil palm yield for Eket (1989 – 2018)

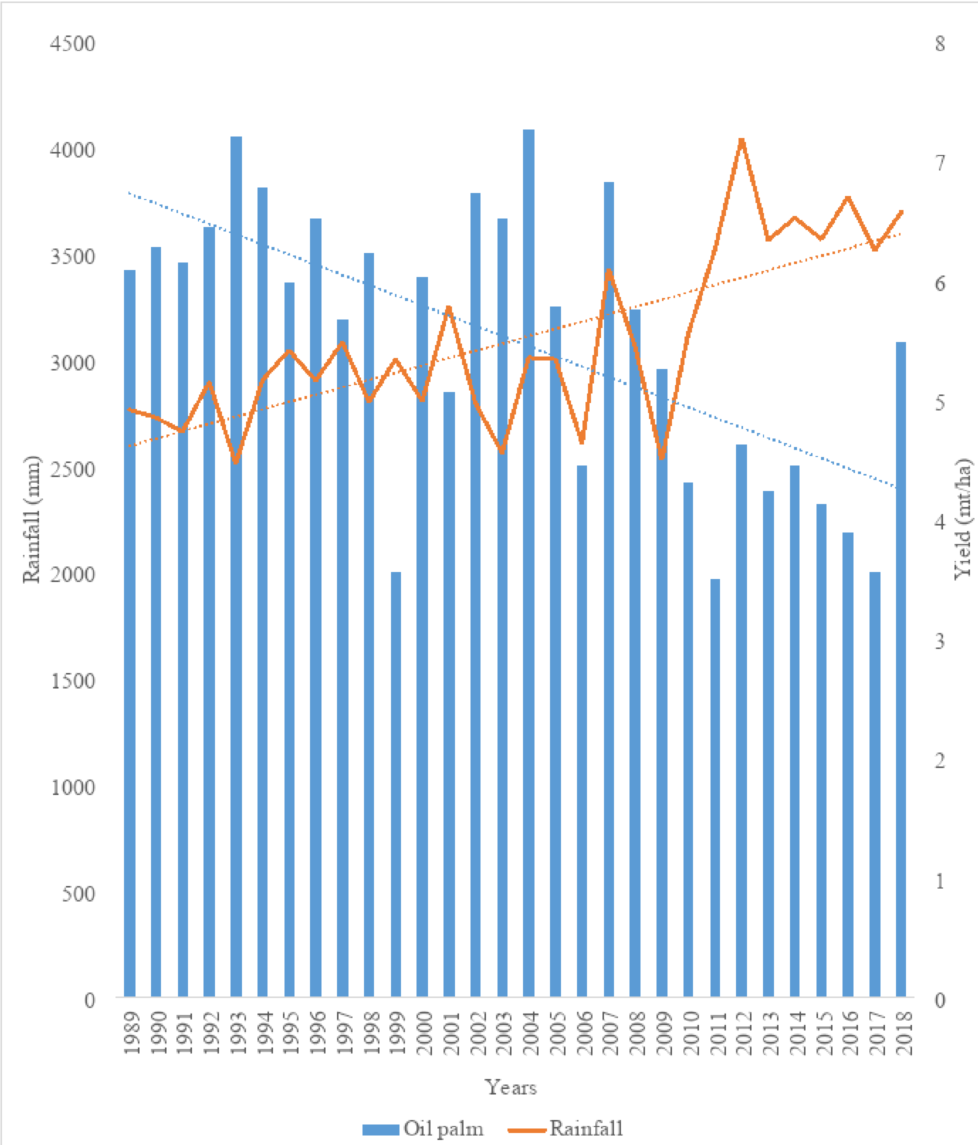

Fig. 5: Trend of rainfall and oil palm yield for Oron (1989 – 2018)

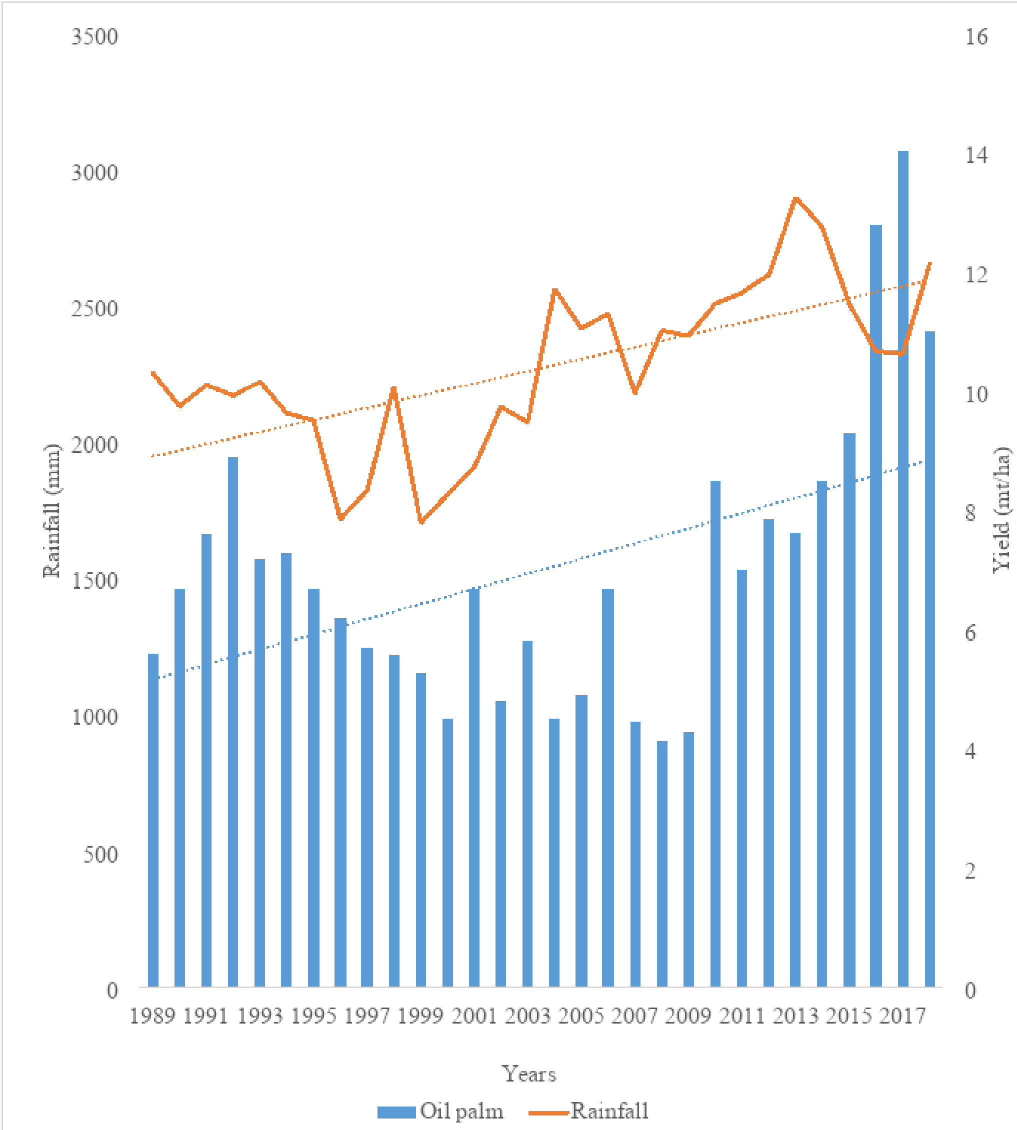

Fig. 6: Trend of rainfall and oil palm yield for Uyo (1989 – 2018)

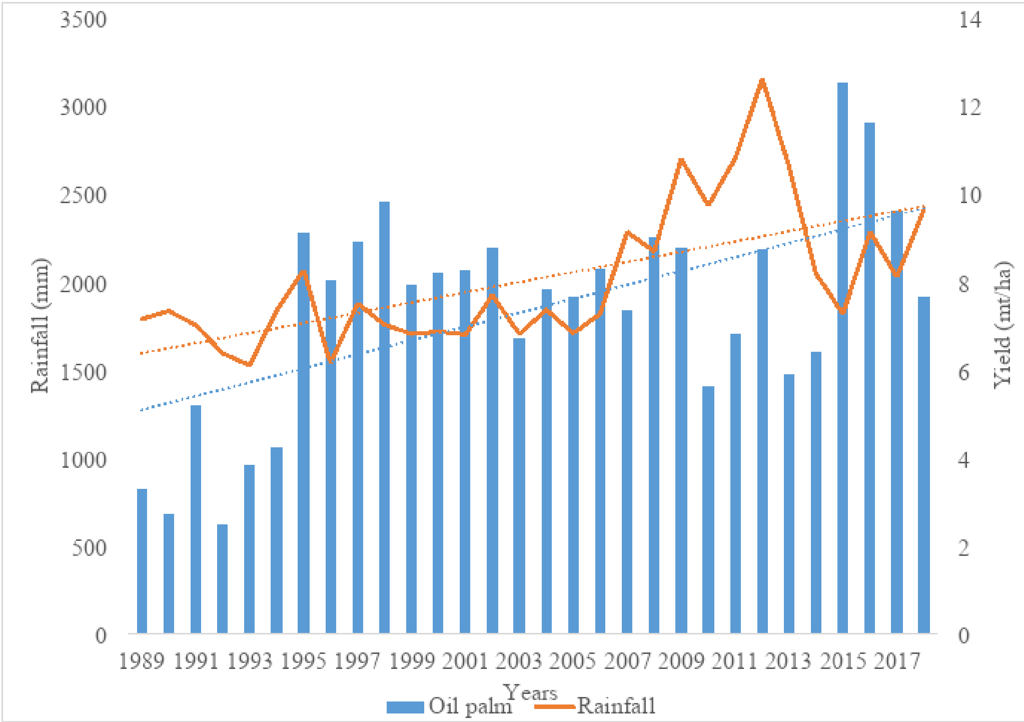

Fig. 7: Trend of rainfall and oil palm yield for Ikot Ekpene (1989 – 2018)

CONCLUSION

Rainfall influenced oil palm production alongside with other climatic variables. The study provides good insight into the influence of rainfall on oil palm yield in Akwa Ibom State. The results revealed that there is a significant increase in rainfall trends in all areas of Akwa Ibom State. Also, the yield of oil palm has increased in relation to rainfall in Uyo and Ikot Ekpene; while the yield of oil palm decreases in Eket and Oron. The decrease in the yield of oil palm may be attributed to an increase in rainfall and vis-visa. Therefore, sustainable production of oil palm could be achieved in upland areas of Uyo and Ikot Ekpene and in other areas with similar rainfall distribution pattern.

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Poor growth and chromosomal aberrations in soybeans (*Glycine max* L. Merril) caused by spent auto-engine oil-polluted soil

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ABSTRACT

Soybean (*Glycine max* L. Merril) is cultivated in Nigeria for its nutritive, diverse domestic and industrial importance. Spent auto-engine oil is disposed indiscriminately on lands in Nigeria and huge amount of refinery effluent is released into the environment which pollutes both terrestrial and aquatic ecosystems, with adverse effects on crop growth and yield. This study investigated the effects of spent engine oil (SEO) on the growth and chromosomes of soybean. Soybean (TGX-1448-2E and local variety) were planted in pots filled with sandy-loam soil treated with 0, 0.1, 0.4 and 0.7% v/w SEO concentrations, in completely randomized design with six replications. Data were collected weekly on growth parameters. Cytological examination of the plant cells was conducted at four weeks after planting to investigate chromosomal aberration. Data were analyzed by ANOVA. Similar seed germination percentage was observed in both treated and untreated soils for both varieties although, the rate was higher in TGX-1448-2E (95±0 - 96±0.7%) than local variety (70±0.7 - 71±0.7%) among the four treatments. Treatments 0.4 and 0.7% SEO caused significant ($p \leq 0.01$) reduction in plant height, number of leaves, leaf length and leaf width whereas, 0.1% did to reduce growth parameters. The SEO polluted soils, especially at 0.4 and 0.7%, showed cytotoxic effects on soybean as they reduced chromosome numbers from 36-40 to 21-27), reduce cell division, mitotic index (68.5-70 to 20.8-22.6%) and produced 30.9 to 31.7% aberrated cells in both varieties. This study indicates that spent oil pollution, as low as 0.4%, is phytotoxic to soybeans.

INTRODUCTION

Nigeria is one of the major petroleum producing countries in the world, having oil as the mainstay of its economy (Adenipekun *et al.*, 2008). Over the years, exploration and exploitation of petroleum in Nigeria has brought so much pollution to the environments. A huge amount of refinery effluent is released into the environment which pollutes both terrestrial and aquatic ecosystems. However, pollution emanating from spent engine lubricating oil has been reported to be more widespread and prevalent than that of petroleum (Odjegba and Sadiq, 2002). Spent auto-engine oil is a waste produced from automobile workshops, mechanical and electrical engine repairer's shops after servicing vehicles, power generating sets and other types of engines (Okonokhua *et al.*, 2007). Spent engine oil (SEO) is obtained during routine maintenance of automobile and power generating engine and often indiscriminately disposed into gutters, municipal drainage systems, open vacant plots and lands in Nigeria by auto-technicians and allied artisans with workshop on the roadsides and open place (Anoliefo and Vwioko, 2005). Ahamefule *et al.*, (2017) reported that oil (petroleum) in soils has deleterious effects on biological, chemical and physical, properties of the soil depending on the dose, type of the oil and other factors. The spent oil has been reported to contain increased amount of heavy metals. Adverse effects of SEO on crops have been earlier reported. Agbodigi (2010) reported poorer germination response of cowpea with increasing dose of SEO.

Soybean (*Glycine max* L. Merril) is one of the most valuable, versatile, and nutritionally important legumes globally. It can be grown under a wide range of climatic conditions, using a variety of management practices, and for diverse purposes (Shea *et al*., 2020). Nigeria is the second largest producer of soybean in Africa, after South Africa, with annual production of about 600,000 tonnes (FAOSTAT, 2020). It is increasingly cultivated in Nigeria due to its high nutritive, and diverse domestic and industrial importance (Qiu and Chang, 2010). The key advantages of soybean are its high protein content, minerals and insoluble fiber (Fabiyi, 2006; Riaz, 2006). It is a good source of several vitamins and minerals, including vitamin K1, folate, copper, manganese, phosphorus, and thiamine (Fabiyi, 2006).

The capacity of SEO to inhibit cell division, reduces mitotic index and causes chromosome aberrations, and reduce growth has also be envisaged in some crops (Obute *et al*., 2016). Chromosomal aberration includes changes either in chromosome structure or number. Alterations in the chromosomal structure can be caused by breaks of DNA, DNA synthesis inhibition and modification in the DNA replication (Leme and Marin-Morales, 2009). In the absence of telomeres, chromosomes turn out to be "sticky" which may join to other fragmented chromosomal ends. Tanti *et al*., (2009) and Obute *et al*., (2016) have shown that heavy metals in SEO have strong toxic effects on soybean plants. Meanwhile, there is limited information on the growth retardation of soybean by SEO polluted soils while its potential cytotoxic impact on the crop is yet to be fully assessed. This study thus investigated the effects of SEO on seed germination, plant growth and chromosomal stability of soybean.

MATERIALS AND METHODS

Sources of planting materials The study was carried out at the experimental plot of the Department of Biological Sciences, Bells University of Technology, Ota, Ogun State Nigeria. The two soybean genotypes used were improved variety TGX-1448-2E sourced from the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan, Oyo state Nigeria and local variety obtained from "Oja Oba" market, Abule Egba, Lagos State Nigeria.

Soil treatments, planting and seedling maintenance

Sandy loam soil was collected at 15 cm depth (top-soil) from fallow land in Bells University of Technology, Ota, Ogun State. The SEO used was obtained from vehicles undergoing service maintenance at automobile workshop in Ota, Ogun State. The oil was left for three days to thicken before use in soil treatments. About 5 kg of the soil was weighed into 8-inch (20-cm) plastic pots and four soil treatments: 0, 0.1, 0.4 and 0.7 % v/w of SEO were prepared using of 0, 5, 20 and 35 ml SEO concentrations per 5 kg soil. The treated soils were left for 24 hours before planting so as to penetrate the soil. Five seeds were sowed per pot and seedlings were thinned down to two on the nineth days. There were 24 pots per variety, making a total of 48 pots arranged in a completely randomized design with six replications. The study was conducted between January and April, 2020. The potted plants were maintained by daily watering and weed control was carried out manually. Insect pests were managed with Cypermethrin insecticide ('Cyperforce', 10% EC) at 4 m/l sprayed four times at two weeks interval, starting from four weeks after planting (WAP). Growth parameters were recorded weekly from 1 WAP.

Cytological assessment of the root tips of soybeans

At 4 WAP, seedlings were uprooted and the root tips of the plants of both varieties were excised and washed with sterile distilled water. Root tips were collected from the treated and untreated (control) plants at 10am. The root tips samples were directly fixed in 3:1 ethanol (96 %) to acetic acid for 24 hr or 48 hr to arrest cell in metaphase without any pre-treatment. The fixed root tips were hydrolyzed in 18 % HCl for 5 minutes in order to degrade cell wall. The root cells were prepared for the chromosome counting using Squash method according to Ostergren and Heneen (1962). The cells were stained with FLP ORCEIN solution for 2 hr to allow enough dye accumulation. The prepared samples, mounted between slides and coverslip, were observed under 40X and captured using a compound light microscope at 100X, for each soil treatments. About seven (7) individual cells on different slides at metaphase stage were prepared from the plants and used to count the number of chromosomes and the average from the seven individual cells observed were used to evaluate the number of chromosomes counted. Another prepared samples, mounted between slides and cover slip were observed for total cells, including dividing cells and aberrated cells (chromosomal aberrations) under 100X magnification using the trinocular microscope (Euromax Microscopen, Spain) and cytologically observed photos were taken from the attached digital camera.

Data collection

Data were collected on seed germination rate at 7 days after planting (DAP) and plant height (cm), number of leaves, leaf breadth (cm) and leaves length (cm). Data were also taken on chromosome number at metaphase stage, number of cells, number of dividing cells and number of aberrated cells using cytologically observed photos through counting as earlier mentioned.

Data analyses

Seed germination rate was determined by the ratio of the number of germinated seeds to the total number of seed sown, expressed in percentage (Ahamefule *et al*., 2017). Data on growth parameters were subjected to analyses of variance (ANOVA) using the PROC GLM statement of Statistical Analysis System, version 9.2 (SAS, 2008) and means were separated using least significant difference ($p \leq 0.01$). For cytological analysis, a total of 1000 cells were counted at 100X magnification for different phases of cell divisions to check for chromosomal aberrations. Data on the cytological effects of the SEO on cell division and chromosomes number of soybean seedlings were estimated using the mitotic index (M.I.) and the chromosomal aberrations calculated according to the formulae described by Bakare *et al.* (2000) as follows:

$$\text{Mitotic index (MI \%)} = \frac{\text{Total number of cells in division}}{\text{Total number of analysed cells}} \text{ x } 100$$

$$\%\ \text{aberrated cells} = \frac{\text{Number of aberrated cells}}{\text{Total number of cells in division}} \times 100$$

RESULTS AND DISCUSSION

Effect of oil polluted soils on seed germination

The seeds of both soybean varieties (TGX-1448-2E and local variety) germinated in the untreated soil and those treated with 0.1, 0.4 and 0.7 % v/w SEO. Germination of seeds was observed from 4 to 7 DAP which was earlier (4 to 5 days) in the 0, 0.1, 0.4 % treatments but delayed (6 to 7 days) in 0.7 % SEO treated soils. Similar germination rate was observed in all the oil-treated and untreated soils for each soybean varieties whereas, percentage seed germination of TGX-1448-2E in the four treatments, were generally significantly higher (95±0 - 96±0.7 %) than that of the Local variety (70±0.7 -71±0.7%) (Table 1). This is contrary to the report of Katsivela *et al.* (2005) on hindrance to seed germination by SEO polluted soils. The inhibitory effect of SEO on germination has been reported to be dose dependent (Agbogidi and Ilondu, 2013) and the SEO concentrations evaluated in this study were lower than the 1 % (Agbogidi, 2010) and 3 % v/w (Ahamefule *et al.*, 2017) reported to have inhibited seed germination. The lower seed viability of the local variety obtained from the market than the improved variety might be due to poor seed storage conditions, or insect and pest damage to the seeds (Grau *et al*., 2004).

Growth parameters inhibition of soybean by spent engine oil polluted soil

The SEO treated soils produced chlorosis and reduced plant height, number of leaves, leaf width and leaf length of soybean. The trend of growth from the first to fourth WAP (Figure 1(a- d) showed higher plant height and number of leaves from untreated soil (control) than the SEO treated soils in both varieties. The two growth parameters reduced with increased treatment, with 0.7 % SEO producing the least growth. This treatment also showed high retardation in plant height from week one to two indicating stunted growth. The 0.1 % SEO did not show reduction in number of leaves whereas 0.7 % reduced the number of leaves of local variety and TGX-1448-2E from 2 and 3 WAP, respectively.

Table 1. Percentage germination of soybean seeds planted in spent engine oil (SEO) contaminated soil

Variety	SEO concentration (%)	Seed germination (%)
TGX-1448-2E	0	96 ± 0.7a
	0.1	96 ± 0.7a
	0.4	95 ± 0.0a
	0.7	95 ± 0.0a
Local variety	0	71 ± 0.7b
	0.1	70 ± 0.0b
	0.4	70 ± 0.7b
	0.7	70 ± 0.7b

Means with the same letter are not significantly different by LSD ($p \leq 0.01$)

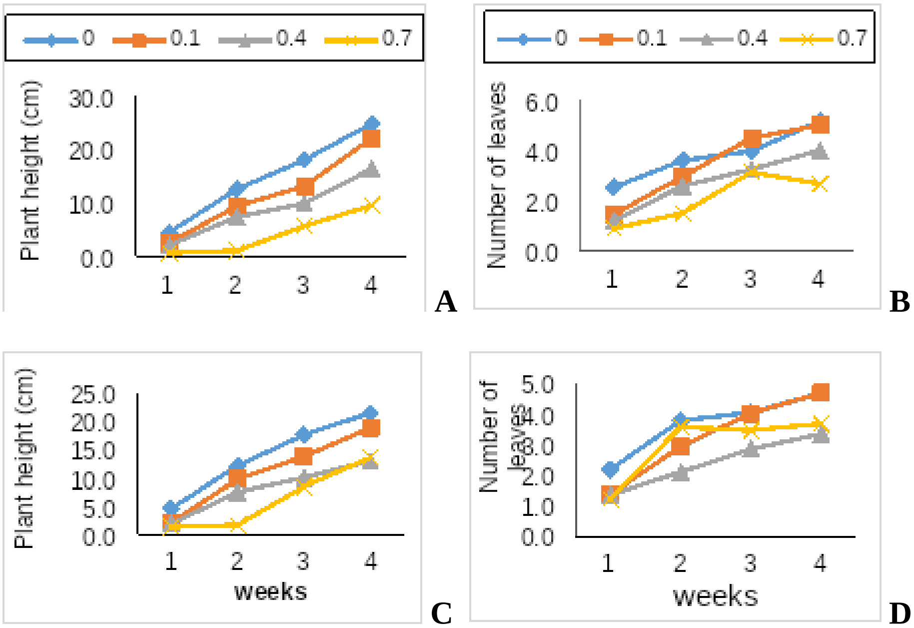

Figure 1 (A - D). Effect of spent engine oil treated soils on the rate of plant height and number of leaves of soybean varieties for four weeks: A and B = plant height and number of leaves of TGX-1448-2E, C and D = local variety

There were significant differences ($p \leq 0.01$) in plant height, number of leaves, leaf width and leaf length of the two varieties. For TGX-1448-2E, highest plant height of 24.9 ± 0.9 cm was observed in untreated soil (control), whereas 0.7 % SEO produced the least (9.6±8.0 cm) (Table 2). Similar trend was observed in the other growth parameters. However, there was no significant difference in the yield parameters produced by the untreated soil (control) and 0.1 % SEO in all the parameters evaluated in both soybean varieties, with the exception of plant height of the local variety. This implies that 0.1 % SEO did not significantly reduce growth parameters (Table 2).

The inhibitory effects of SEO on crop growth have been previously reported (Agbogidi and Ejemete, 2005; Ekpo *et al*., 2012). The lower growth parameters might be due to reduction of nutrient elements with increasing oil concentration in the soil (Odjegba and Atebe, 2007). For instance, a study on maize *(Zea mays*) showed that oil pollution made nutrient elements, especially macronutrients, in the soil unavailable for plants use (Udebuani *et al*., 2017). Another possible cause of the plant growth inhibition by SEO is either increased acidity in the soil or reduction in the catalase activity (Achuba and Peretiemo-Clark, 2007). Such increased acidity has be attributed to the production of organic acids due to microbial metabolism of the substrate (Udebuani *et al*., 2017).

The presence of some heavy metals in the SEO soil might have also contributed to the observed chlorosis and stunted growth of soybeans (Okonokhua *et al*., 2007). High concentration of cadmium as well as nickel, lead, copper and zinc have been reported in oil polluted soil and cadmium is highly toxic to plants, with its toxicity manifested in form of chlorosis, necrosis, stunting and reduced photosynthesis (Udebuani *et al*., 2017). Oil pollution usually has adverse effects on the physical, chemical, and biological properties of the soil (Agbogidi and Ejemete, 2005; Ahamefule *et al*., 2017). This response of soybean and its ability to tolerate most of the mineral contents in the oil polluted soil has presented the crop with high potential for phytoremediation of oil contaminated soils (Sanderson *et al*., 2018).

Table 2 Effects of spent engine oil (SEO) on growth parameters of Soybeans at week four

Variety	SEO concentration (%)	Plant height (cm)	No. of leaves	Leaf width (cm)	Leaf length (cm)
TGX-1448-2E	0 (control)	24.9±0.9a	5.2±0.5a	2.9±0.2a	7.6±0.7a
	0.1	22.2±0.6ab	5.0±0.5a	2.8±0.3ab	5.7±1.4ab
	0.4	16.4±1.0bc	4.0±0.5ab	2.5±0.3ab	5.8±1.6ab
	0.7	9.6±8.0c	2.7±2.3b	1.5±1.4b	3.4±2.9b
Local variety	0 (control)	21.5±0.5a	4.6±0.3a	2.7±0.2a	5.9±0.1a
	0.1	18.8±1.1b	4.7±0.8a	2.7±0.3a	5.7±0.9a
	0.4	12.9±0.3c	3.3±0.3b	2.3±0.3ab	4.5±0.4b
	0.7	13.5±0.4c	3.7±0.3b	2.1±0.1b	3.4±0.2c

Means with the same letter within column per variety are not significantly different by LSD ($p \leq 0.01$)

Cytotoxic effects: Chromosomal aberration: cell division, aberrated cells and mitotic index

The SEO treatments produced cytotoxic effects on soybean. The number of chromosome, number of cells in division, number of aberrant cell and mitotic index of the two soybean varieties varied among the SEO treatments. The number of chromosomes counted at metaphase stage of the soybean cells decreased with increase in concentration of SEO (Table 3). The numbers were higher (36 to 40) for plants from untreated soil in both soybean varieties which is within the expected chromosome number of soybean (2n=40) (Hailemariam and Tesfaye, 2018) than that from 0.7 % SEO treated soil (21 to 27). This implies that 0.4 and 0.7 % SEO treatments were cytotoxic to soybean plants indicating an aberrant changes in chromosomal numbers. Cytological observation of root tip cells of soybean raised in SEO polluted soil showed some cellular and chromosomal aberrations (Figure 2 (A – E)).

Table 3. Chromosome counts of soybean (2n = 40) root cells at metaphase stage at four weeks of growth
in spent engine oil (SEO) treated soils

Variety	SEO concentration	No. of chromosomes from seven cells at metaphase							
	(%)	1	2	3	4	5	6	7	mean
TGX-1448-2E	0 (control)	38	40	37	40	38	39	40	39
	0.1	34	32	32	35	32	29	37	33
	0.4	25	25	33	24	27	24	30	27
	0.7	22	23	26	22	23	27	21	23
Local variety	0 (control)	38	39	36	40	40	36	37	38
	0.1	29	30	33	29	36	31	32	31
	0.4	24	29	25	23	26	27	31	26
	0.7	22	21	20	26	24	23	25	23

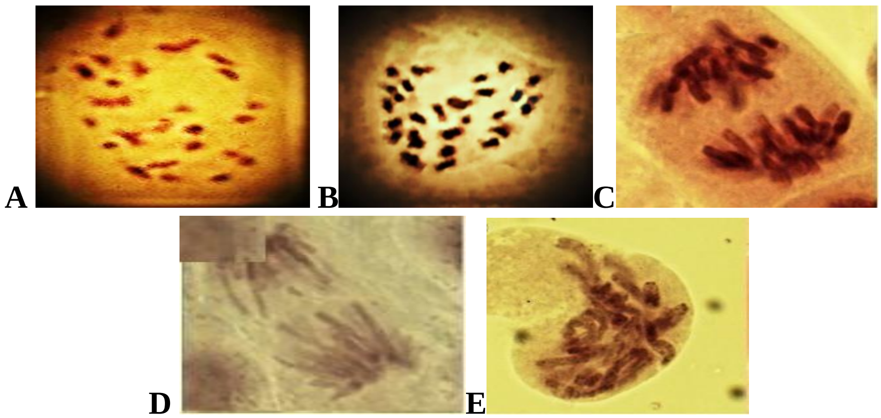

Figure 2 (A - E). Aberrations in mitotic cell division of soybean caused by spent engine oil polluted soil: A and B = stickiness of chromosomes at metaphase, C = stickiness with chromosome fragments D = bridge and laggard chromosome, E = chromosome bridge and disturbance in metaphasic spindle

The number of aberrant cells or percentage abnormality (% aberrant cells) was highest at the highest SEO concentration whereas, no aberrant cell was detected from untreated soil (control) (Table 4). The mitotic index (M.I.) also decreased with increase in SEO treatments. The highest values of 70 and 68.5 were obtained from untreated plants (control) whereas the least (22.6 and 20.8) were observed from the highest SEO concentration (0.7 % v/w) for TGX-1448-2E and local soybean varieties, respectively. The decreased mitotic index also indicated a strong trend of inhibition of cell division in soybean by oil treated soils. The observed reduction in the frequency of dividing cells might be due to lack of spindle fibres formation that would have introduced the cells from one stage to another (Timothy *et al.*, 2014). Borah and Talukdar (2002), similarly reported that the frequency of cells and chromosomal aberrations (abnormalities) was associated with the toxicity of the spent engine oil.

Such oil polluted soil have produced an abnormal increase in size (hypertrophy) of new cells of maize plant which later ruptured as the cells grew older (Udebuani *et al.*, 2017). Previous studies have indicated the cytotoxicity of plants at 1 % of SEO concentration and above (Agbogidi, 2010; (Ahamefule *et al.*, 2017). However, the observed phytotoxicity of SEO on soybeans, even at a concentration of less than 1 %, has not be previously reported.

Table 4. Mitotic index and percentage aberrated cells of soybean planted in spent engine oil (SEO) treated soil

Variety	SEO concentration (%)	Total cells observed	No. of cells in division	No. of aberrated cells	Aberration (%)	Mitotic index (%)
TGX-1448-2E	0 (control)	1000	700	0	0	70
	0.1	1000	560	38	6.8	56
	0.4	1000	355	49	13.8	35.5
	0.7	1000	226	70	30.9	22.6
Local variety	0 (control)	1000	685	0	0	68.5
	0.1	1000	515	36	6.9	51.5

	0.4	1000	368	53	14.4	36.8
	0.7	1000	208	66	31.7	20.8

CONCLUSION

This study shows that discharge of SEO on lands, farmlands and water bodies, has inhibitory and detrimental effects on the growth parameters of soybean plants. Soil pollution at 0.4 and 0.7 % v/w SEO resulted in significant reduction in the plant growth parameters. Discharge of spent auto-engine oil as low as 0.4 % in soil produced phytotoxic effects on soybean some which include: reduced mitotic index activity, cell and chromosomal aberrations in forms of Sticky chromosome, bridge and laggard chromosomes. This cytotoxic effects necessitate the need for soil test for oil pollution of farmlands before farming, especially those with close proximity to auto-mechanic stations. There is also the need for public health education and oil pollution campaign in Nigeria on the danger of indiscriminate discharge of oil and possible regulation and other environmental friendly solution to spent oil disposal by the government. This is important so as to ensure environmental and human health, especially on the high levels of heavy metals contamination in food crops. Field studies on the level of growth inhibition and reduction in the productivity of soybean by oil spillage is important for effective crop yield loss prevention.

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Studies of the Physicochemical Parameters of Topsoil Sampled From the Vicinity of an Industrial Estate, Southwestern Nigeria

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ABSTRACT
This study examined the physicochemical properties of topsoil that were collected around the vicinity of Ota industrial estate, Southwestern, Nigeria. The study is important for understanding the potential for translocation of contaminants within the soils of the study area. Eleven representative samples including control were obtained and examined for parameters such as pH. Soil organic carbon SOC), Soil organic matter (SOM), granulometric fractions and cation exchange capacity (CEC). The result from vicinity of industrial area showed pH value to range between 4.93 to 6.68, SOC ranged between (0.30 to 1.81)% while SOM was found to be between (0.52 to 3.11)%. The granulometric property showed the soil to be mostly sandy, followed by clay and silt. CEC was low and found to range between (1.90 to 5.50)cmol/Kg. The result for control showed pH to be 6.97, SOC and SOM were 2.49% and 4.28% respectively. CEC was found to be 6.23cmol/Kg. The values obtained from the vicinity of the industrial estate could be attributed to improper waste disposal within the industrial estate. Therefore, a more stringent legislation about environmental management, as well as studies about the mineralogical composition of soils is recommended.
Key words: Physico-chemical parameters, soil, Industrial estate, Nigeria

INTRODUCTION
Soil is the dynamic link between the biosphere and lithosphere and constitutes a practically nonrenewable (very low rate of formation) natural resource, with a key role for the environment and for the agriculture (Moraetis et al., 2016). Soil pollution is one of the major problems that threatens plant and people's lives. Anthropogenic activities such as seepage from landfills or solid waste, discharge of industrial waste into the soil, percolation of contaminated water into the soil, rupture of underground storage tanks or excess application of pesticides or fertilizers (Seifi et al., 2010) could change the physicochemical properties of the soil. Properties such as pH, organic matter, cation exchange capacity (CEC) and soil texture could be affected. Soil pH affects nutrients availability and the optimal condition for this is at pH 5 to 7 (Arp and Krausse, 2006). The potential for elements present in soils and sediments to be mobilized/immobilized and be redistributed depends on several factors such as organic matter, type and amount of clay, pH and the prevailing redox conditions; and pathways. These elements can easily be mobilized and

transmitted through for example, water and the food chain to humans (Manga et al., 2017). Therefore, there is great need to investigate the physicochemical properties of soils for agricultural and environmental purposes.

Despite growing rates of industrialization, many developing third world countries pay too little attention to environmental issues. This is evident in the location of many industrial facilities near residential areas and the non-availability of adequate regulatory and enforcement measures to guard against pollution. One of such industrial facilities co-located with residential areas is the Ota Industrial/Housing Estate in the southwestern region of Nigeria (Figure 1). There are forty seven different factories within the estate dealing with a wide range of products that include chemicals, pharmaceuticals, plastics, paper and pulp, and metals/steel. A third of these industries which represents the primary industrial types are metal-based industries, producing either iron rods, steel or galvanized pipes and sheets. Co-located with these industrial types at very close proximity are residential houses. Emissions of particulates into the atmosphere, and improper disposal of solid wastes are common practices within the estate. This paper investigates the physicochemical parameters in topsoils within the vicinity of Ota industrial estate, South western Nigeria.

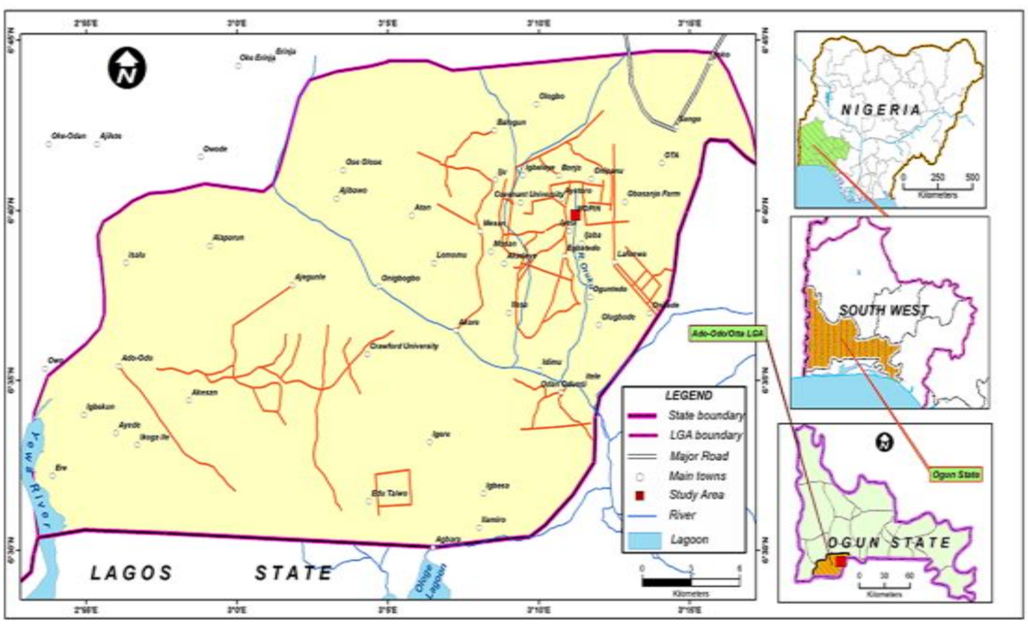

Figure I: Map of Ado Odo Ota local government showing the sampling location

MATERIALS AND METHODS

Description of Study Locations

The Ota industrial/housing estate, located on latitude $6^{0}32'$N and longitude $2^{0}57'$E, is sited on a 22.8 km^2 expanse of land in tropical southwestern region of Nigeria.

Sampling

Topsoils were sampled from five core industrial areas (TSI), three residential areas (TSR), two vegetation areas (TSV). Control sample (TSC) was obtained from other residential areas located about 1 km from the industrial estate and not affected by industrial activities. Field sampling were conducted at a depth of 0 to 15cm with the aid of an auger. The samples were collected into a black polythene bag and labeled.

Sample Preparation and Analytical

The soils were air-dried in a clean room in the laboratory and then passed through a 2 mm mesh sieve. Soil pH was determined by the electrometric method using a 1:1 soil water mixture (IITA, 2001). The hydrometer method was used for measuring soil granulometric properties (sand, silt and clay) (Bouyoucus, 1951), while the classical redox back-titrimetry procedure was used to determine soil organic matter content (Walkey and black, 1934).

CEC was determined by ammonium acetate, pH 7.0 method (FAO, 2022)

RESULT AND DISCUSSION

Table I: Physico-Chemical Properties of Soils in the vicinity of Ota Industrial Estate, South western, Nigeria.

	TSI-1	TSI-2	TSI-3	TSI-4	TSI-5	TSR-1	TSR-2	TSR-3	TSV-1	TSV-2	TSC
pH	5.63	4.93	5.27	5.41	6.68	5.49	5.72	5.46	5.51	5.92	6.97
% Organic Carbon	0.34	0.30	0.77	0.50	0.98	1.81	0.58	1.41	1.47	1.77	2.49
% Organic Matter	0.58	0.52	1.32	0.86	1.68	3.11	0.99	2.43	2.53	3.05	4.28
% Sand	79.7	75.6	85.1	87.0	85.4	71.2	72,3	79.6	76.1	71.8	75.6
% Clay	13.2	20.6	12.3	11.6	12.4	17.1	13.9	17.7	11.8	10.8	21.2
% Silt	7.12	3.8	2.6	1.4	2.2	11.7	13.8	2.70	12.1	17.4	3.20
Cation exchange capacity (cmol/Kg)	4.50	4.30	4.60	3.25	2.75	1.90	3.25	4.75	4.00	3.26	6.23

The results of the physicochemical properties of soils in the vicinity of Ota industrial estate, Southwestern Nigeria was presented in Table I.

The soil pH value within the vicinity of the industrial estate showed pH to vary between very strongly acidic (TSI-2) to slightly acidic (TSI-5) according to the ratings from Hazelton and Murphy (2007). pH of the control (TSC) was neutral. The degree of acidity and/or alkalinity is considered a master variable that affects nearly all soil properties-chemical, physical and biological. While some organisms are unaffected by a rather broad range of pH values, others may exhibit considerable intolerance to even minor variations in pH (Obasi et al., 2012). The soil pH also affects the availability of various nutrients, toxic elements and chemical species to plant roots. The pH is therefore a very good guide to some expected nutrient deficiencies and toxic effects (Brady, 1984). In a similar study, Osakwe and Okolie (2015) found that the soil pH had a mean value of 5.15 ± 0.48.

According to the rating established by Hazelton and Murphy (2007), the soil organic carbon (SOC) contents were in the low to high range. Low value of SOC were recorded in the core industrial area (TSI-1 to TSI-5), only TSR-2 recorded low SOC while others were high. High content of SOC and SOM were recorded in the control sampleSoil organic carbon is the basis of soil fertility. It releases nutrient for plant growth, promotes the structure, biological and physical health of soil, and is buffered against harmful substances. Increasing soil organic carbon helps in mitigating climate change, improves soil health and fertility. SOC also has influence on releasing or holding CO_2 from the atmosphere through various channels, thereby possibly affecting the atmosphere-soil carbon balance (Wu et al., 2001; Jiang et al., 2007). The low values could be attributed to improper waste disposal and the sandy nature of most of the soils. Particle size was dominated by sand, followed by clay and silt, which revealed coarse soils with low supply of nutrients and moisture (Osakwe and Okolie, 2015). Etim and Onianwa 2013 recorded low value for organic carbon and organic matter in a similar study

The cation exchange capacity (CEC) was rated low in all the soil samples studied except in the control. This rating was done according to Benton (1999); Hazelton and Murphy 2007. CEC is the capacity of the soil to hold and exchange cations. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. As such it is a major controlling agent of stability of soil structure, nutrient availability for plant growth, soil pH, and the soil's reaction to fertilisers and other ameliorants. A low CEC means the soil has a low resistance to changes in soil chemistry that are caused by land use. Fomenky, et al 2018 also recorded low CEC in soils around some rivers in Cameroon.

CONCLUSION

The result from the study area showed the soil pH to vary between very strongly acidic to slightly acidic except for the control that was neutral. The SOC and SOM ranged from low to high. CEC showed low value for soil sample but high CEC content in the control. The values obtained from the vicinity of the industrialestate could be attributed to improper waste disposal within the industrial estate. Therefore, a more stringent legislation about environmental management, as well as studies about the mineralogical composition of soils is recommended.

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Response of Barley to different levels of salt and moisture stress

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ABSTRACT

Barley (*Hordeum vulgare*) grown in Tigray regions usually undergoes salinity problem due to poor water quality and drought stress at the different stages of growth. Study was conducted at the green house of the Department of Crop and Horticultural Sciences, Mekelle University, Ethiopia on response of barley to different levels of salt and moisture stress. Treatments used were T_0 = 3 litres of water + No salt, T_1 = 1 litres of water + 150g of salt, T_2 = 2 litres of water + 100g of salt, T_3 = 3 litres + 50g of salt, T_4 = 1 litre of water + 50g of salt, T_5 = 2 litres of water + 150g salt and T_6 = 3 litres of water +100g salt) and replicated five times. The experiment was designed in a Randomized Complete Design. Data were taken on germination percentage, plant height, leaf area, fresh and dry weight of the shoot biomass, fresh and dry weights of the roots and length at harvest. Data collected were analyzed by Analysis of Variance (ANOVA) and means comparisons were done at 5% level of probability. From the result,T_0 gave the highest response from all parameters evaluated, followed by T_4 and T_3 at early stages and T_6 later while T_1 gave the least values. Also, T_3 produced significantly higher results in all parameters measured compared with others. Thus, Barley roots length, fresh and dry biomass weights were significantly affected with increasing salt concentration. Hence, moisture is needed in barley production and yield is negatively influenced by the amount of salt concentration in the soil.

Key words: Arid environment, Barley, Yield, Moisture rates, Salt concentration

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one of the oldest domesticated crops where consumption is as early as 1500BC (Smith, 1995). It is an essential crop in Africa, especially in the arid and semi-arid regions and serves as a staple food and feed crop for humans and livestock respectively.

Inadequate moisture and salinity are considered major environmental factors limiting the growth and productivity of crops. Prolonged periods of drought stress resulted in major losses in grain yield of rain fed crops in Ethiopia and characterized by a semi-arid Mediterranean climate. Similarly, rain is scarce, irregularly distributed, and varies from one year to another in the Tigray region (FAO, 1999).

Salinity has a two-fold effect on plants; the salt in the soil solution decrease the availability of water to the roots (osmotic stress) and the salt taken up by the plant can accumulate to toxic levels (ionic stress) in plant tissues (Munns *et al*., 2006). In a similar vein, James *et al*. (2002) further reported that salt stress unfavourably affected plant growth and productivity at all developmental stages with the views that salinity decreases seed germination, retards plant development and reduces crop yield.

Irrigation as a source of water supply can cause salinization, water logging and soil degradation, which are evident in many areas of the world (Wang, 2004). At the same time, water stress could result in lower nutrient mining and disturbance of metabolites transportation to the grains. To this end, Salinity affects leaf water potential, leaf osmotic potential and leaf pressure potential of plants. As salinity increases, leaf water potential and leaf osmotic potential decreases whereas leaf pressure potential increases (Acquaah, 2002). Barley is known to be tolerant to salinity and moisture stress, the objective of this study was to determine physiological factors that makes barley tolerate salt and moisture stress and its response to different levels of salinity and moisture stress. Hence, the purpose of this study was to evaluate the effects of different salt concentration and precipitation rates on the growth and development of barley.

MATERIAL AND METHODS

The investigation was conducted in the screen house of the Department of Crop and Horticultural Sciences, Mekelle University, Ethiopia in two consecutive seasons. The barley cultivar, *Birguda* variety, a native of Tigray region in Ethiopia was used as test crop for the project.

Base-line analysis of the soil sample was carried out to validate the status of the soil. The soils were sieved and filled into plastic pots. The pots were perforated to enhance proper drainage of water and arranged in the greenhouse. The experiment was designed in a Randomized Complete Design and replicated five times.

Seeds obtained from the seed-bank of the Department of Crop and Horticultural Sciences, Mekelle University, Ethiopia were selected based on physical appearance (size, colour and length) to ensure viability. Saline culture solutions with different osmotic potential were prepared by mixing NaCl and $CaCl_2$ in a 2:1 Molar ratio at different concentrations (0, 50, 100 and 150 grams) and water volumes (1, 2, and 3 litres) respectively. The prepared solutions were added to the pots accordingly and left till the following day, after which five seeds were planted per pot and water was added in line with the treatment. The treatments include: T_0 = Control (No salt + three litres of water) ; T_1 = 1 litter of water + 150g of salt concentration,T_2 = 2 litres of water + 100g of salt concentration; T_3 = 3 litre of water + 50g of salt concentration; T_4 = 1 litres of water + 50g of salt concentration; T_5 = 2 litres of water + 150g of salt concentration and T_6 = 3 litres of water + 100g of salt concentration. The same quantity of water was added at two days intervalup to the time of harvest. Parameters measured included germination percentage. The leaf area (cm^2) were calculated from the TIFF file using a public domain software (Scion image) as suggested by O'Neal et al. (2002). Seedlings were harvested to determine root and shoot lengths (cm), root and shoot fresh weights (kg seedling^{-1}) and finally root and shoot dry mass (kg seedling^{-1}). Shoot length was measured from the soil surface up to the highest point of the longest leaf. Fresh shoot biomass and dry weight of the roots per pot as well as root length at harvest. Root length was measured from the crown down to the tip of the root. The dry mass was determined after the roots and shoots were dried in an oven at 80 °C for 48 hours in paper bags.

Data obtained were subjected to analysis of variance and means were separated using Statistical analysis of data was carried out with the use of JMP-5 soft ware's.Means comparisons were done at 5% level of probability with the use of Turkey –Kramer HSD approach.

RESULT AND DISCUSSION

The soil analysis revealed the nutrient status and nature of the soil (Table 1). There was low organic carbon, organic matter, high pH value of 8.2 and high electrical conductivity (EC) value indicating high alkalinity and salinity. The final germination percentage and root length of barley reduced significantly with increased salt concentration (Table 2). Treatment T_0 gave the highest germination (96%) and root length (13.12 cm) while the use of T_1 gave the least germination (44%) and root length (5.32 cm) respectively. The results suggested that Nacl salinity inhibits seed germination and root seedling growth of barley. Treatment T_0 is significantly different from other treatments on all parameters measured at $p < 0.05$.

Growth and development of barley was strongly affected by salinity levels; as the increased salt concentration resulted in reduction of germination percentage, plant height, leaf area, as well as both the shoot and root biomass weights (Table 3).The response of T_2, may be as a result of the toxicity effect owing to increasing Na^+ and Cl^- concentration and uptake rate of mineral nutrients. This result corroborated with the findings of Yousofinia *et al.*, 2012 in barley on wheat who indicated that with increased concentration of NaCl, both root and shoot lengths decreases. From Table 3, the ability of barley seed to germinate and survive at different levels of salt concentration is an indication that the crop exhibited salt tolerance. The increase in productivity resulting from an increase in water quantity supplied as revealed on all parameters measured confirms the work of Bello (2008) who stated that different levels of moisture content of the planting areas influenced the availability of nutrients that enhance plant growth.

CONCLUSION

The result indicated that barley seeds exhibited salt tolerance during germination period and at all stages of development. It also showed that both water and salt are major factors determining the production of crop in semi-arid to arid or water deficit environments. The marked improvement observed with increased water quantity which reduced the effect of salinity by improving vegetative growth, biomass yield and root length suggested that efficient use of irrigational water would aid crop performance in dry land farming.

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Table 1: Chemical properties of the soil

Characters	Values
pH (KCl)	8.20
Temp (^{0}C)	22.50
Electrical Conductivity (Sm-^{1})	432.87
Avail. Phosphorus (mg/kg soil)	25.74
Organic Carbon (%)	0.91
Organic Matter (%)	1.56
Total Nitrogen (%)	0.08
Na (cmol/kg soil)	1.08
K (cmol/kg soil) "	0.07
Ca (cmol/kg soil) "	20.20
Mg (cmol/kg soil) "	13.10
Cation Exch. Capacity (cmol/kg soil)	61.75
$CaCO_3$ (%)	1.62

Table 2: Response of barley germination percentage and root length to different levels of salt and moisture

Treatment Water + Salt	Germination %	Root length (cm)
T0=3litres + 00	96.00a	13.12a
T1=1 litre + 150g	44.00c	5.32e
T2=2 litres + 100g	72.00b	6.84d
T3=3 litres + 50g	76.00ab	9.48b
T4=1 litre + 50g	84.00ab	7.10d
T5=2 litres + 150g	64.00bc	3.02f
T6=3 litres +100g	68.00b	7.46c

*means followed by the same letter are not significantly different at $p<0.05$.

Table 3: Effect of different treatments on plant height, and leaf area and biomass production of barley

Treatments Water + salt	Plant height (cm)	Leaf area (cm)	Fresh shoot weight (kg)	Dry shoot weight (kg)	Fresh root weight (kg)	Dry root weight (Kg)
T0 =3litres + 0	34.00a	30.80a	3.20a	2.30a	2.26a	0.84a
T1=1litre+ 150g	12.40d	10.00e	1.50c	0.80d	0.16e	0.10c
T2=2litres+100g	22.40c	20.20c	1.70c	1.32cd	0.76cd	0.18c
T3=3litres+ 50g	27.20b	28.80ab	2.56ab	1.92ab	1.32b	0.40b
T4= 1 litre + 50g	28.40b	20.00cd	1.58c	1.04d	0.66d	0.20bc
T5=2 litres + 150g	14.00d	16.80d	1.52c	1.18cd	0.56d	0.31bc
T6=3 litres + 100g	20.40c	26.80b	2.24bc	1.66bc	1.08bc	0.84a

*means followed by the same letter are not significantly different at $p<0.05$.

Synchronizing Nitrogen Release from Organic Sources with Plant N Uptake in the Northern Guinea Savanna Alfisols

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ABSTRACT

Nitrogen management practice is imperative in order to harness the benefit of organic matter application to improve soil fertility and crop productivity. Incubation studies of different organic manures: compost, cow dung, municipal solid wastes and poultry were investigated to determine their N release pattern in the soil. The organic manures were subjected to incubation studies in the laboratory for 0, 3, 7, 14, 42, 56, 84 and 98 days. Ammonium, Nitrate and net N concentrations; and N release of these materials were determined at different incubation periods. Result indicated that Poultry manure recorded a significantly higher net N release than all other organic manures. The N release increases linearly from 0 to 98 days with pattern showing poultry manure being > compost > municipal solid waste > cow dung. However, cow dung recorded the highest NO_3^- N concentration among the various organic manures. Results also showed that highest nitrate concentration in municipal solid waste and cow dung were observed at 7 days after incubation whereas highest concentration in poultry and compost were observed at 14 days after incubation. It therefore followed that best time for application of municipal solid waste and cow dung to synchronise with plant uptake is 7 days whereas for poultry manure and compost will be 14 days.

Key words: N – release, Nitrate and Ammonium concentration, Northern Guinea Savanna and Organic sources

INTRODUCTION

Soil organic matter (SOM) content of most savanna soils is reported to be very low (Chude *et al*., 2012) which made it susceptible to major chemical, physical and biological limitations thereby reducing crop yields. Furthermore, organic matter in these soils is continuously depleted as a result of Agricultural intensification. This therefore calls for organic matter application to these soils which plays important role in maintaining soil fertility and productivity. Soil fertility needs to be maintained in order increase crop yields, reduce environmental pollution, and achieve sustainable agricultural intensification. SOM is a storehouse and supplier of nutrients such as nitrogen, phosphorus, potassium and sulfur to crops (Schulten and Schnitzer., 1998), and improves the physical, chemical, and biological properties of soils. These SOM decompose via mineralization to release the nutrients required for crop growth and development (Diacono and Montemurro, 2010).

In order to obtain maximum economic value from these organic matters and minimize nitrate pollution potential, N management practices must be adjusted for expected N release from the organic matter. The amount of N released to crops depends on the chemical composition of organic matter e.g. N content, carbon: nitrogen ratio, and contents of cellulose and hemicelluloses, lignin, and polyphenols (Mohanty *et al*., 2011) and on the physical, chemical, and biological properties of soil microbes (Manojlovic *et al.*, 2010). Organic amendments with high N contents and low C:N ratios mineralize sufficient N to satisfy plant growth (Cordovil *et al* 2005). Conversely, N can be immobilized in organic matter with lower N contents and higher C:N ratios (Manojlovic *et al*., 2010).

Most farmers do not have knowledge on when these organic materials should be applied to the soil. Organic manures are simply taken and dumped in the farm without considering type, amount, source and time of application. They generally assume that N released is the same for all organic manures and at the same time. This would, as a result, lead to wrong estimation of N availability to plants. Consequently, the time of N release may not be synchronized with N uptake by the plants. This leads to N loss in the soil system without plants getting it. It is therefore important to manage these organic manures appropriately to avoid loss of N in soil and facilitate timely N uptake by plants. An understanding of the nutrient release dynamics would enable farmers to manage the organic resources in a manner that optimizes nutrient uptake and ultimately crop productivity. The aim of this study therefore, is to investigate N release of some organic materials in the Northern Guinea Savanna.

MATERIALS AND METHODS

Soil Sampling and preparation

A soil sample was collected from Institute for Agricultural Research (IAR) experimental site (N11^{o}10’31.3”, E0073^{o}63’8.9”). The soil was dried, crushed, sieved through 2mm sieve mesh. Eight hundred grams (800g) was put into a jar (1 liter) where the various treatments of organic materials were added.

Incubation Studies

The soil samples for incubation study was dried, crushed, sieved through 2mm sieve mesh. Eight hundred grams (800g) was put into a jar (1 litre) where the various treatments were added which included Compost, Cow dung, Municipal Solid Waste and Poultry manure. Each manure which is equivalent to 200 mg kg N kg^{-1} soil (that is 15.24g of Compost, 13.01g of Cow dung, 18.39g of Municipal sewage waste and 3.15g of Poultry manure) was added to the soil. The soil and manure were then mixed in the jar by stirring with a spatula and then repacked to approximately natural bulk density, brought to 60% WHC with deionized water. The moisture content was maintained at 60% WHC by weighing it periodically. The set up was incubated for 98 days. The jars were covered with lids but aerated for 1 h each day throughout the incubation period.

All treatments were replicated 4 times in a completely randomized design (CRD). There were therefore 4 treatments (Compost, Cow dung, Municipal waste and Poultry manure) and 4 replicates giving 16 number of set ups.

A 10 g soil sample was taken from each jar at 0, 3, 7, 14, 28, 42, 56, 84, 98, days after incubation and NH_4^+-N and NO_3^--N were determined therefrom. Nitrogen mineralization (release) from manure was calculated using Nitrogen mineralization model to predict N release at various incubation periods:

$$\mathbf{N_t = N_0\ ([1 - e^{-kt}])}\ \text{..................}\ \textbf{Equation 1}$$

Where:

$\mathbf{N_m}$ = the amount of N mineralized at time t [µgg^{-1}].

$\mathbf{N_o}$ = the initial amount of potentially mineralizeable N [µgg^{-1}].

k = first order rate constant day^{-1} taken to be 0.011 day^{-1}.

RESULTS

Effect of manures and incubation periods on NH_4^+ and NO_3^- and net N release

The analysis of NH_4, NO_3 and total N release is presented in Table 1 below. It showed that there were significant differences among the organic material. The organic manure N release showed that highest NH_4^+ release was recorded by Poultry manure and was significantly higher than all the other manures. It also revealed that NO_3^- release of poultry manure was higher that other manures but was statistically at par with compost manure. Similar trends were observed when the net mineralization was computed (Table 1).

Table 1: Effect of organic manures on Nitrogen release (mg.Kg^{-1})

Organic Manure	NH_4^+-N	NO_3^--N	Total Nitrogen
Control	4.07d	28.04c	32.39d
Municipal Waste	6.16c	31.11b	37.28c
Compost	9.03b	53.75a	62.78b
Poultry	15.19a	55.87a	71.06a
Cow dung	8.01b	27.58c	35.59c
SE ±	0.37	0.86	1.03

Means with the same alphabet are statistically similar. SE = standard Error.

The figure 1below showed the net N release in organic manures during the incubation period. It showed that N release linearly increased with incubation time. Poultry manure recoded the highest N release rate. The poultry manure was at par with compost manure from day 3 to day 14 (Fig 1). At day 28, 42, 84 and 98 days, poultry manure differed statistically higher than compost in net mineralization.

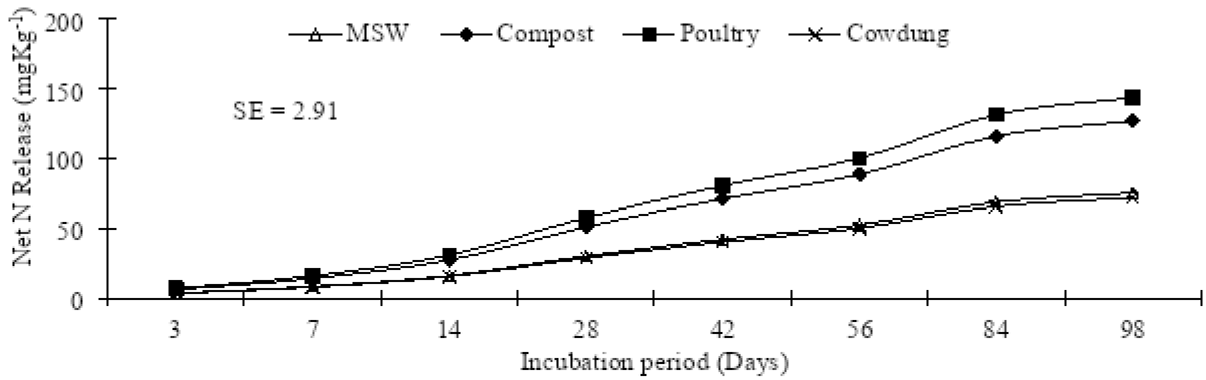

Figure 1: Effect of incubation period on Net N release in organic manures.

Effect of manures and incubation periods on NH_4^+ and NO_3^- concentration

The result of the analysis indicated that generally, there were significant variations among the organic manures in the N concentration in soil (Fig 2). Cow dung recorded the highest NH_4 concentration and was significantly higher than other organic manures. Municipal solid wastes and compost manures recorded statistically similar NH_4 dynamics and were significantly higher than poultry manure. However, the poultry manure recorded a significantly higher that municipal solid waste and cow dung in NO_3^- concentration but statistically at par with compost. Generally, the concentrations of NH_4 in all the organic manures were peak at day 14 after which it declines (Fig 2). The NO_3 concentration however varies with the manure. While concentration of NO_3 in poultry and compost were peak at day 7, that of municipal solid waste and cow dung were at day 14. Regardless of incubation period and type of manure, the concentration of NO_3–N was higher than NH_4–N.

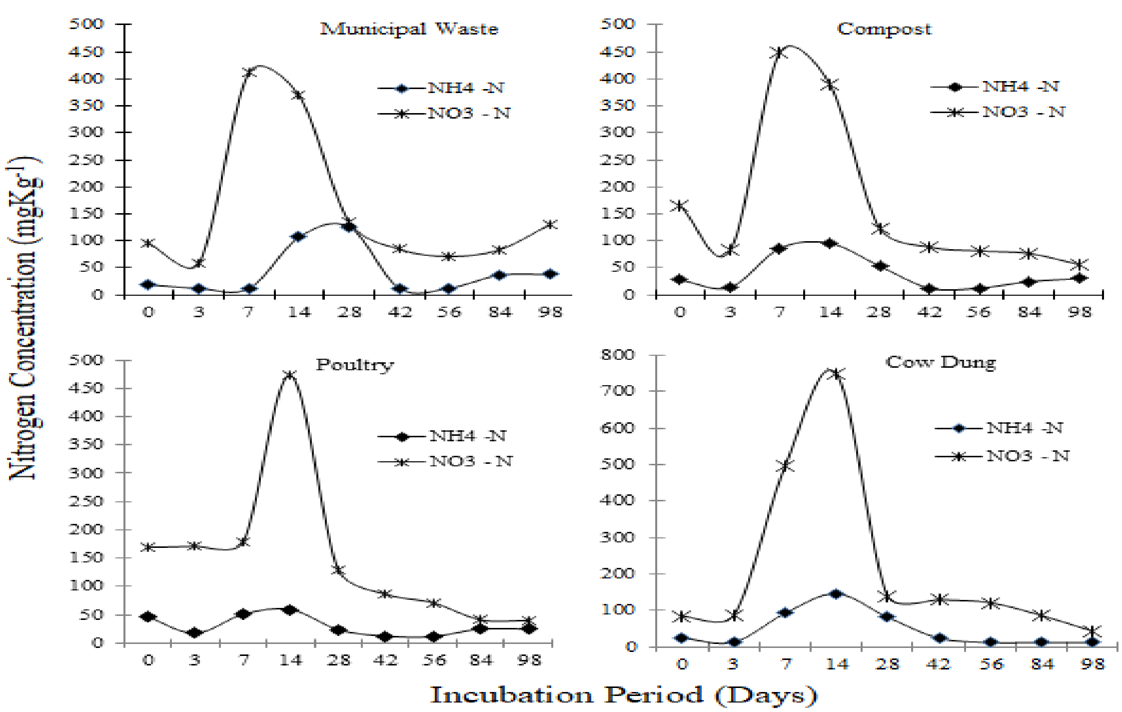

Figure 2: Effect of incubation period on Nitrogen concentration in organic manures.

DISCUSSION

The higher NH_4 release reported in this study in poultry manure was in agreement with the report of Alizadeh and Fallah (2012) which said poultry manure-treated soil had higher mineralization rate than cow manure treated soil. This could be as a result of soil changes in degree of dissociation of NH_4^+/NH_3, which becomes favourable to massive nutrient release and the decomposition of poultry manure rich in microorganism facilitated by moisture also led to faster release of NH_4^+. It also agrees with the report of Li and Li (2014) who suggested that N availability of cattle manure was lower than chicken manures.

The higher release of NO_3 in poultry and compost reported in this study could be as result of lower C/N ratios of the manures which connote the presence of simple organic compounds such as urea and uric acid which decompose very easily during the first few days after application in the soil. Similar results were reported by Maerere *et al.* (2001) who observed that applications of higher rates of animal manure resulted into increased levels of net available N.

The concentration of NH_4–N and NO_3–N linearly increased from day 3 (14.11 mg kg^{-1} NH_4 and 91.57 mg kg^{-1} NO_3) up to day 14 (97.27 mg kg^{-1} NH_4 and 423.15 mg kg^{-1} NO_3) while at day 28, there was a sudden decline in the NH_4 and NO_3 nitrate concentration up to day 56 while at day 84 and 98 there was a linear increase. The decline of soil NH_4^+-N within 28 days can be explained by rapid immobilization combined with nitrification and denitrification as also explained by Li and Li (2014). This is because microorganisms prefer NH_4 –N for their growth and utilize NO_3^-–N when NH_4–N concentrations are lower than 1µg N g^{-1} soil. Working on N release of chicken manure, pig manure and cattle manure, Calderon *et al*. (2005) also found the rapid decline of soil NH_4–N in a short period of time after incubation. This finding corroborates with the finding of this study. However, the content of NO_3^- measured gave higher concentration than NH_4^+-N with incubation time. This was because NH_4 was prone to losses through immobilization, volatilization, fixation and nitrification.

CONCLUSION

This study showed that nutrient concentrations and release vary differently with organic manure and therefore availability of nutrient for plant uptake will also differ. Results revealed that nutrient in poultry manure and compost would be most available (7 days) faster than cow dung and municipal solid waste (14 days). This therefore calls for importance of the knowledge nutrient management in timing the application of these organic materials. This will help in synchronising the nutrient availability with plant nutrient uptake in soil–plant systems.

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Evaluation Of Different Sources Of Organic Manure On Selected Soil Chemical Properties And Growth Parameters Of Sweetpotato In Umudike, Abia State

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ABSTRACT

A study was carried out to evaluate effects of different sources of organic manure (poultry manure, cow dung, goat droppings, pig waste and oil palm bunch) on selected soil chemical properties (soil pH, Organic matter, Total nitrogen, available phosphorous and potassium) and some growth parameters of Orange flesh Sweetpotato in Umudike. Treatments (poultry manure, Cow dung, Goat droppings, Swine waste and Control) were applied at 8 t/ha, laid out in RCBD and replicated 3 times. Plant data were collected at 4, 8 and 12 weeks after planting, while soils for analysis were collected at 12weeks after planting, air dried, sieved and analyzed for some chemical properties (pH, Organic matter, total Nitrogen, Available Phosphorus and Potassium).
Data collected from field and laboratory were analyzed statistically using GENSAT. The result showed that application of different organic manure significantly ($p<0.05$) improved soil pH, organic matter, soil nitrogen, available phosphorous and potassium when compared with the control. The result showed that application of organic manure from different source improved soil chemical properties as well as growth parameters considered. The extent of influence on the chemical properties was found to be dependent on the organic manure source.

Key words: organic manure, soil chemical properties, sweetpotato

INTRODUTION

Agricultural soils in the humid tropics are marginal, fragile and infertile especially those that fall under Oxisols and acidic Ultisols (Ikpe *et al*, 2014). Apart from the economic cost, the use of chemical fertilizers under continuous cultivation in the tropics have been found to be unable to sustain crop yield (Makinde and Ayoola, 2012). Continuous application of inorganic ferttilizer has been found to deplete soil organic matter and reduction in crop yield and serious environmental degradation and decline in soil productivity (Adeniran *et al*., 2004). Numerous studies have shown that organic manure including livestock manure, plant biomass and sewage sludge can be used to improve soil fertility and productivity (Ikpe *et al.*, 2003). Animal (cattle, sheep, goats, poultry, and pig) manures have been shown to contain large amounts of organic matter (OM), Nitrogen (N), phosphorus (P), Potassium (K) which are essential for soil fertility and crop growth. Poultry manure, cow dung, goat droppings and swine waste are generated in large quantities from livestock farms and are commonly used by farmers across Nigeria. There is a need to compare the effectiveness of these organic manure on soil chemical properties and growth parameters of sweetpotato. Therefore, the objective of this study was to evaluate effect of different organic manures on selected soil chemical properties and growth parameters of sweetpotato at Umudike.

MATERIALS AND METHODS

The study was carried out in Umudike, Ikwuano LGA of Abia State Southeastern Nigeria. Umudike is located on latitude 05°29' N, longitude 07°33' E and 122m above sea level. The climate is essentially humid tropical with an average annual precipitation of 2164mm. There are two distinct seasons; the rainy season which starts in March/April and ends in October. Then the dry season which starts in November and ends in March subsequent year (NRCRI Meteorology Centre, 2021).The site of the experiment was cleared, ploughed, harrowed and ridged mechanically with tractor before planting. Treatments, poultry manure, Cow dung, Goat droppings, Swine waste, and Oil Palm bunch were applied at 8t/ha and laid in Randomized Complete Block Design (RCBD) on 3m x 3m beds, replicated 3 times. Sweet potato vines obtained from National Root Crops Research Institute Umudike, were planted at 30cm x 30cm.

Plant (growth) parameters were determined at 4, 8 and 12 weeks after planting (WAP); using the standard methods. Soil samples were collected after 12 weeks, air-dried and sieved with 2mm sieve and stored for lab. Analysis. Soil pH was determined in H_2O using glass electrode pH meter at a soil liquid ratio of 1:2.5 as explained by Udo *et al.* (2009). Soil Organic Carbon was determined by Walkley *and* Black wet oxidation method as modified by Udo *et al*., (2009). Organic Matter was obtained by multiplying organic carbon values by conventional Van Bellema factor (1.724). Total Nitrogen was determined by Kjeldhal digestion method (Bremmer and Mulvaney 1996). Available Phosphorus was determined by Bray 2 method as described by Bray and Kurtz (1945). Exchangeable potassium (K) was determined by Flame Photometer using ammonium acetate extraction (NH_4AOC) method according to Udo *et al*. (2009).

Soil and plant data were subjected to analysis of variance for CRBD experiment, significant treatment means were separated using the least significant difference at 5% probability level

RESULT AND DISUSSION

Result of Pre-Cropping Soil Sample of the Study Area

Result of the pre-cropping soil (table 1) showed that soil texture of the study area is sandy loam with pH of 4.9, (acidic) and low in most of the basic nutrient (Ca= 3.6 cmol/kg, N = 0.093%, K = 0.211 cmol/kg, p = 14.5 mg/kg, OM = 1.95 %) required by sweetpotato for good growth and yield.

Soil Chemical properties

The result (table 2) showed that soil pH ranged from 4.7 to 6.7, with poultry manure given highest value (6.7) followed by 6.5 and 6.0 from swine and cow dung. While palm bunch and goat droppings gave 5.9 and 5.7 respectively. Though higher than control 4.7. The ability of the organic manure to positively influence soil pH is in the following order; poultry manure > Swine waste > Cow dung > Palm bunch > Goat droppings > Control. Organic matter significantly ($p<0.05$) increased as a result of applying different organic manure. Cow dung gave highest value of 4.88% followed by goat droppings (4.39%) and poultry manure (4.37%) while the lowest value among the manures was 3.96% from palm bunch. Total nitrogen ranged from 0.070 to 0.394%. The result showed that application of organic manure significantly ($p<0.05$) improved total nitrogen over the control. Poultry manure gave highest value of nitrogen 0.394%, followed by swine waste and cow dung (0.386 and 0.294%). Goat droppings and palm bunch gave 0.244 and 0.215% while lowest value of nitrogen (0.072 %) was recorded on control. Available phosphorous ranged from 11.1 to 25.1 mg/kg, with highest value obtained from swine waste (25.1 mg/kg) followed by poultry and cow dung (24.6 and 20.8 mg/kg) while control gave lowest value of 11.1 mg/kg. potassium ranged from 0.090 to 0.410 cmol/kg with palm bunch manure given highest value of potassium (0.410 cmol/kg) followed by poultry manure and swine waste (0. 402 and 0.380 cmol/kg. while cow dung and goat droppings recorded lower values of potassium among manures tested. The result obtained from this study is in accordance with the findings of Makinde and Ayoola, 2012.

Plant Parameters

The result shows that vine length increased significantly ($p <0.05$) across the month of the experiment (figure 1). At 4 weeks after planting (WAP), poultry manure gave highest value (26.33 cm) followed by swine waste and cow dung (16.67 and 16.33cm) while lowest value of vine length was recorded on control (11 cm). At 8 WAP and 12 WAP, poultry manure gave highest values of 69.3 and 121 cm followed by 55.9 and 109.6 cm from swine waste. While lowest value of vine length was recorded on control (4 WAP=11, 8WAP= 39.7 and 12WAP= 57.3 cm). Number of leaves ranged from 11 to 16 at 4WAP, 29 to 66 at 8WAP and 54 to 134 at 12 WAP. Number of leaves were significantly ($p<0.05$) improved by the application of organic manures, poultry manure gave highest number of leaves at 4WAP (16), 8WAP (66) and 12 WAP (134) followed by swine waste 4 WAP = (15), 8 WAP= (60) while lowest number of leaves were recorded on control.

CONCLUSION

The result showed that application of organic manure from different source improved soil chemical properties as well as growth parameters considered. The extent of influence on the chemical properties was found to be dependent on the organic manure source.

Table 1: Result of Pre-Cropping Soil Sample of the Study Area

Soil properties	Value
Sand (g/kg)	700
Silt (g/kg)	140
Clay (g/kg)	160
Texture	Sandy loam
pH (H_2O)	4.9
Available phosphorus (mg/kg)	14.8
Nitrogen (%)	0.093
Organic carbon (%)	1.13
Organic matter (%)	1.95
Calcium (cmol/kg)	3.6
Magnesium (cmol/kg)	1.0
Potassium (cmol/kg)	0.211
Sodium (cmol/kg)	0.103
Exchangeable acidity (cmol/kg)	1.72
Effective Cation Exchange Capacity (cmol/kg)	6.63
Base Saturation (%)	74.75

Table 2: Evaluation of different sources of organic manure on selected soil chemical properties

Treatment	pH (H_2O)	Org. M %	N %	Av. P mg/kg	K cmol/kg
Poultry manure	6.6	4.37	0.394	24.6	0.402
Cow dung	6.0	4.88	0.294	21.8	0.340
Goat Droppings	5.7	4.45	0.244	20.4	0.270
Swine waste	6.5	4.18	0.386	25.1	0.380
Palm bunch	5.9	3.96	0.215	19.7	0.410
Control	4.7	1.88	0.072	11.1	0.090
LSD (0.05)	**0.14**	**0.44**	**0.019**	**1.05**	**0.032**

Note: Note: N= total nitrogen, Av. P = available phosphorous, K= potassium, Org. M= organic matter

Figure 1: Effect of different source organic manures on vine length

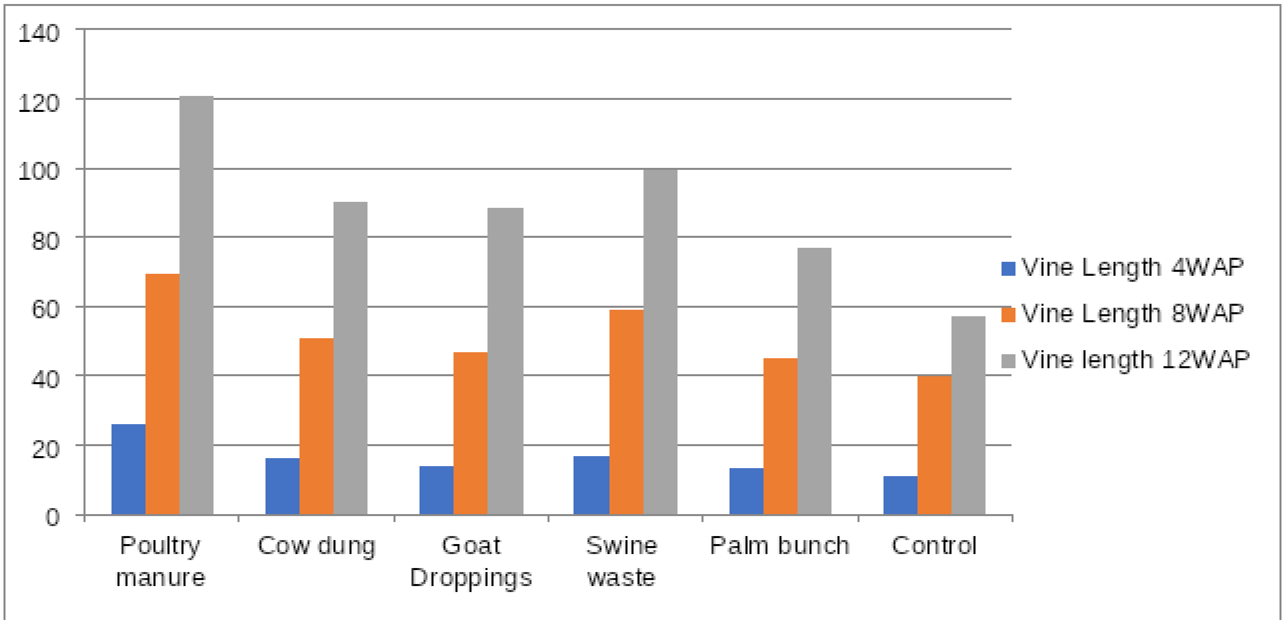
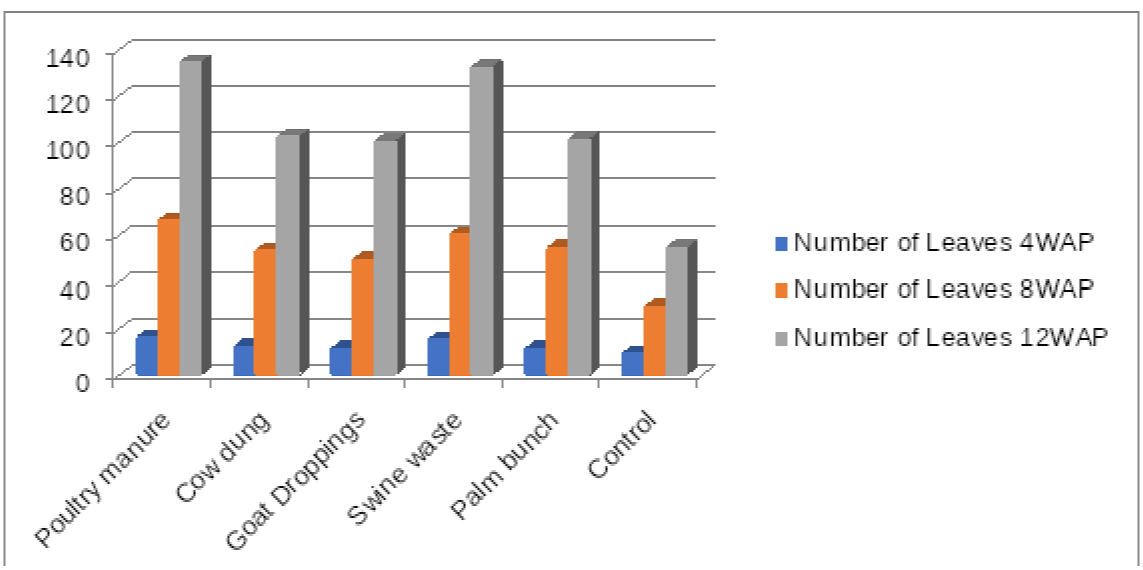


Figure 2: Effect of Different Source of Organic Manure on Number of Leaves



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Effects of industrial wastes on heavy metal deposit of composite soil in Oluyole industrial area, Ibadan

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ABSTRACT

This study investigates the effects of industrial wastes on heavy metal deposit of composite soil in exide battery industry. The heavy metal content of composite soil from industrial wastes discharge were determined. This is done to give appropriate advice to industrialists on possible hazard of improper effluents treatments.

The samples for the study were collected at exide battery industry, located at Oluyole Industrial Area, Ibadan. The soil samples were collected by using soil auger. There werefour treatments, replicated five times. The treatment was represented by the distance of collection. The soil was collected at 0 metres point, 3 metres point, 6 metres point, and 50 metres as control. There were five points of soil collection at each of the four treatments. This was done at 20 cm distance. The measurements were on industrial waste discharge area. Each of the composite soil sample collected was sieved to 2 mm size and grounded to powdery form. Powdered soil samples were chemically homogenized in the laboratory, for heavy metal analysis. The digested composite soil samples were analyzed using atomic absorption spectrophotometer (AAS) (model ZA-3300), for the determination of the level of heavy metals present. All the values were subjected to analysis of variance (ANOVA), using statistical package for social science, and mean separated by Ducan multiple range test, with significant difference level of $p \leq 0.05$.

The finding of the study reveals that soil samples taken at Om had the highest Zn concentration of 2.63 mg/kg above the FAO permissible level and was significantly higher than the soil samples collected at 3m, 6m and 50m which had 1.29mg/kg, 1.42 mg/kg and 0.60 mg/kg respectively at $p \leq 0.05$. However, soil samples taken at 3m and 6m were not significantly different form each other at $p \leq 0.05$, while soil samples taken at 50m had the lowest significant value (0.60mg/kg).

INTRODUCTION

Environmental issues have become important to all mankind. Anthropogenic activities that releases pollutant to the planet earth include: industrialization, the use of atomic bomb, nuclear plants, improvements in agriculture, health, food processing, automobiles, jet and space travels, the plastics revolution, deforestation and desertification, information technology and many others.The compelling need for the awareness of these problems is imperative in the sense that environmental pollutionis trans-boundary in nature (Ahmed *et al.*, 2009; Oyelola*et al.*, 2013).Effects of industrial effluents is one of the most important problems around the world in which thousands of millions of world inhabitants suffer health problems (Martinez *et al.*, 2001). The recent years have witnessed significant attention being paid to the problems of environmental contamination by a wide variety of chemicals including the trace metals (Hisseien *et al.*, 2015). Trace metals enter into our environment from both natural and anthropogenic sources (Ahmed *et al.*, 2009). They contaminate food sources and accumulate in both agricultural products and sea foods through water, air and soil contamination (Bebson *et al.*, 2013). All trace metals are toxic at soil concentration above permissible levels (Ahmed *et al.*, 2009). The objective of this study is to determine the level of heavy metal content of composite soil from industrial waste discharge and to give appropriate advice to industrialists on possible hazard of improper effluents treatments.

MATERIALS AND METHODS

The study area was at the Exide battery located at Oluyole industrial Estate, Ibadan, Oyo State, Nigeria. Composite soil samples were collected at industrial waste discharge area of Exide battery, Ibadan. The soil samples were collected by using soil auger at 10 cm deep. The collected soil was put in an envelope and labeled accordingly. In soil samples collection, there were four treatments, replicated five times. The treatment was represented by the distance of collection. The soil was collected at 0 metres point, 3 metres point, 6 metres point, and 50 metres as control. The measurements were done on industrial waste discharge area. At 0 metres point, the soil was collected at 0 – 10 cm deep using soil auger. At 0 meters point, the soil was collected on the same line at 20 cm distance at five different points. This was treatment 1, at 0 cm point. The soil samples for treatments 2, 3, 4 and 5 were collected as done above. Each of the composite soil sample collected was sieved to 2 mm size and grounded to powdery form. Powdered soil samples were chemically homogenized in the laboratory, for heavy metal analysis. The digested composite soil samples were analyzed using atomic absorption spectrophotometer (AAS) (model ZA-3300), for determination of the level of heavy metals present.

Data was collection on the levels of heavy metals (Zn, Pb, Cd, Mn, and Fe) present in the composite soil samples. All the values were subjected to analysis of variance (ANOVA), using statistical package for social science, and mean separated by Duncan multiple range test, with significant different level of $p \leq 0.05$.

RESULTS AND DISCUSSION

Heavy Metal Contents in the Soil at the Industrial waste discharge of Exide battery industry, Ibadan.

There were significant differences in the Zn content/concentration amongst the treatments at 5% level of significance.

Soil samples taken at Om had the highest Zn concentration of 2.63 mg/kg which was significantly higher than the soil samples at 3m, 6m and 50m which had 1.29mg/kg, 1.42 mg/kg and 0.60 mg/kg respectively at $p \leq 0.05$. However, soil samples taken at 3m and 6m were not significantly different form each other at $p \leq 0.05$, while soil samples taken of 50m had the lowest significant value (0.60mg/kg).

There were significant differences in the Pb content/concentration amongst the treatments at 5% level of significance. Soil samples taken at 0m had the highest Pb concentration of 105.60mg/kg which was significantly higher than the soil samples taken at 3m, 6m and 50m which had 61.68mg/kg, 20.82mg/kg and 4.48mg/kg respectively at $p \leq 0.05$. However, soil samples taken at 3m and 6m were significantly different from each other at $p \leq 0.05$ while soil sample taken at 50m had the lowest significant value (4.48mg/kg).
There were significant differences in the Cd content/concentration amongst the treatments at 5% level of significance. Soil samples taken at cm had the highest cd concentration of 5.00 mg/kg which was significantly higher than the soil samples taken at 3m, 6m and 50m which had 0.15mg/kg, 0.02 mg/kg and 0.04mg/kg respectively at $p \leq 0.05$. However, soil samples taken at 3m, 6m and 50m were not significantly different from one another in Cd content.
There were significant differences in the Mn content amongst the treatments at 5% level of significance. Soil samples taken had the highest Mn concentration of 19.50 mg/kg which was significantly higher than the soil samples taken at 3m, 6m and 50m which had 14.05mg/kg, 13.22kg/mg and 8.10kg/mg respectively at $p \leq 0.05$. However, soil samples taken at 3m and 6m were not significantly different from each other at $p \leq 0.05$ while the soil sample taken at 50m had the lowest significant value 8.10 mg/kg.
There were significant differences in the Fe content/concentration amongst the treatments at 5% level of significance. Soil samples taken at 0cm had the highest Fe concentration of 9.40mg/kg which was significantly higher than soil samples taken at 3m, 6m and 50m which had 7.28mg/kg, 3.64mg/kg and 4.20mg/kg respectively at $p \leq 0.05$. However, soil samples taken at 3m and 6m were significantly different from each other at $p \leq 0.05$.These were has recorded in Table 1. From the point source, there was high concentration of industrial waste discharge containing heavy metals. As water carries the wastes from the point source, the concentration of waste discharge reduces. This gives the reason for the difference in the heavy metal contents recorded.

Table 1: Heavy Metal Contents in the Soil at the Industrial waste discharge of Exide battery industry, Ibadan.

TRT	Zn (mg/kg)	Pb(mg/kg)	Cd(mg/kg)	Mn(mg/kg)	Fe(mg/kg)
T1	2.63a	105.60a	5.00a	19.50a	9.40
T2	1.29b	61.68b	0.15b	14.08b	7.28
T3	1.42b	20.82c	0.02b	13.22b	3.64d
T4	0.60c	4.48d	0.04b	8.10c	4.20c

Means with the same letter are not significantly different at $p \leq 0.05$

T1: 0 m, T2: 3 m, T3: 6 m, T4: 50 m

CONCLUSIONS AND RECOMMENDATION

As shown by the progressive decrease in the content of heavy metals in the soil around the discharged area of the industry,it was concluded that there was no proper monitoring of the industrial discharge.It is therefore recommended that government must ensure strict compliance of all industries to proper treatments of their waste discharge. Equally, there must be public enlightenment to the people living around the industrial areas, to be sensitized of the possible health hazard that may likely be generated from the improper waste treatments from these industries around them.

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Changes In Soil Microbial Biomass-C And Yield Of Ginger On Application Of Organic Ammendments

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ABSTRACT

Application of different organic manure in ginger production has various advantages such as improving soil microbial biomass which in turn increases soil fertility and crop yield. Therefore, the impact of four different organic materials (cow dung, saw dust, poultry manure and rice mill waste) on soil microbial biomass, dynamics in soil microorganisms and ginger yield were assessed. The different organic materials seemed to influence the behavior of the bacterial communities after six months as diverse microorganisms which can be considered as plant growth promoters were observed in different treatments such asBacterial species (*Pseudomonas* and *Bacillus spp,Proteus* spp ,*Clostridium spp and others*) and fungi species (*Rhizopus japanus*, *Aspergillus spp, Penicillium spp and others.)* These microorganisms show high versatility in their metabolic capacity and they areknown as intensive decomposers. The dynamics of microbial biomass of carbon was assessed, rice mill waste (RMW) showed significant increase (92.28 mg/kg) in microbial biomass-C at 6th month after planting among other treatments such as sawdust which decreased significantly than rice mill waste (RMW) with 28.23mg/kg at 6th month after planting. Ginger yield responded according to different organic amendments treated soils giving the highest yield on Rice mill waste (RMW) with 8.10kg followed by cow dung with 6.30kg and finally poultry manure (5.4kg) though not significantly different from each other. The least yield was found on saw dust organic amendment (2.07kg) which is significantly different from other treatments. This study shows that analysis of the activities and diversity of soil microorganisms, is necessary to assess the impacts of organic amendments in ginger yield and soil fertility. However, the application of Cow dung (CD) poultry manure(PM), rice mill waste (RMW) serve as the best farming option for improving ginger production and soil microbial activities and hence improve soil fertility.

Keywords: Microbial biomass -C, Ginger rhizomes, organic amendment, microorganisms and yield

INTRODUCTION

Ginger (*Zingiber officinale* Rosc) is among the important widely used spice crops worldwide (Archana *et al*., 2013).The economic part is the underground rhizome which ispungent and used for culinary purposes (Thankamani *etal.*, 2002).

Application of organicmanures has various advantages like improving soil physical properties, water holding capacity and organic carbon content, apart from supplying good quality nutrients (Singh *et al.*, 2009). The productivity of ginger, level of soil microorganisms and rate of soil fertility are declining day by day due to non-judicious and indiscriminate use of inorganic fertilizers.

Soil microorganisms are involved in many biochemical processes and particularly carbon turnover (Buckley and Schmidt, 2003). It is characterized by its rapid turnover compared to the other components of organic matter (Sparling *et al*., 1998). Thus, the microbial communities are an indicator of changes occurring in managed ecosystems. Different organic amendment that are rich in nitrogen and carbon accommodates a lot of microorganisms. These microbial communities produce and use different carbon pools in a dynamic process, release nutrients that are biologically available for plants, decompose toxic materials and also affect the dynamics of organic matter and soil structure. An example is the turnover rate of the microbial biomass and population which is faster than the turnover rate of total soil organic matter (Carter *et al.* 1999).
However, the aim of this study was to assess the impact of different organic amendments on soil microorganisms and their activities as well as the yield of ginger rhizomes.

MATERIALS AND METHODS

The study was carried out in the agricultural field of National Root Crops Research Institute (NRCRI), Umudike. The experiment was conducted in plots set-up as randomized complete block (RCBD) design. Ginger rhizomes were planted on 2cm by 2cm on each plot measured (2mx3m) and each plot was replicated 3 times making it a total of 12 plots. Before the planting, different amendment method were thoroughly mixed accordingly and incorporated in the soil before the planting of ginger.The experiment was designed for the evaluation of agronomic, microbiological and ecological effects of amendments with four different organic material such as Cow dung (CD),saw dust (SD), poultry manure (PM) and rice mill waste (RMW).

Soil sampling

This was done in accordance with the general methods for soil microbiological study (Alexander, 1977). Four top soil samples were collected from a depth of (0-10) cm from each plot (Saeki and Toyota, 2004). Soil samples for analysis were collected at 4th and 6th month after planting

Microbial enumeration

This was done according to the method described by Adarsh *et al.*,(2007) for the isolation of soil microorganisms. While microbial biomass-C was done according to the method described by Ladd and Amato (1989) and Ginger was harvested at the end of 12th month after planting and each treatment was harvested and weigh in kg to determine the ginger yield response.

RESULTS AND DISCUSSIONS

Microbial Enumeration

Bacterial species such as *Pseudomonas* and *Bacillus spp*. have a wide distribution among the treatments except in sawdust (Table 1) and it shows high versatility in their metabolic capacity as they are considered to be among plant growth promoters (Buckley and Schmidt, 2003). Among the fungi, *Rhizopusjapanus, Aspergillus sp, Penicillium sp*.and *Metharizium anosoplie* were also observed among the treatments and they are considered to be the most intensive decomposers (Laughlin and Steven, 2002).

Microbial Biomass-C

In Figure 1, the periodic time graph showed that there are changes during the months study, microbial biomass-C-content varied slightly between the 4th month and the 6th month of study seasons and between different treatments but the differences were not significant except for rice mill waste (RMW) which shows higher microbial biomass-C of 92.28mg/kg and 109.20mg/kg at 4th and 6th month after planting respectively, which is significantly different from other treatments such as sawdust which is significantly lower than rice mill waste (RMW) with 22.10mg/kg and 28.23mg/kg at 4th and 6th month after planting.

Enhancement of microbial biomass-C after organic amendment has been reported during long-term experiments (Garcia-Gil *et al*., 2000) as well as in short-term experiments (Saison *et al*., 2006). Our results showed that over a short length of time, (six months) with different levels of organic amendment microbial biomass-C was seen to increase significantly in RMW among other treatments.

Ginger Yield (Kg)

Ginger yield responded according to different organic amendments treated soils giving the highest yield on Rice mill waste (RMW) with 8.10kg followed by cow dung with 6.30kg and finally poultry manure (5.4kg) though not significantly different from each other. The least yield was observed on saw dust (SD) organic amendment (2.07kg) which is significantly different from other treatments (Fig2). This confirmed the findings of Olayinka and Adebayo (1985) which stated that sawdust has higher propensity to reduce microbial bioload which could be as a result of nitrogen immobilization caused by sawdust, resulting to reduced microbial respiration and hence reduction on yield. According to Amakiri (1982) and Beck *et al*. (2005), soil biochemical and biological processes are critical for ecosystems functioning, as microbes have key roles in organic matter transformations, nutrient cycling, degradation of organic pollutants, including pesticides which affect crop yield.

CONCLUSION

This study shows that analysis of the changes in activities and diversity of soil microorganisms is necessary to assess the impacts of organic amendments in ginger yield and soil fertility. Therefore organic amendments accessed improved the overall soil microbial dynamics which revealed a correlation between microbial biomass and ginger yield resulting in, the higher the microbial biomass, the higher the yield. It therefore concluded that application of Cow dung (CD), poultry manure (PM), rice mill waste (RMW) serve as the best farming option for improving ginger production and soil microbial activities and hence improve soil fertility.

Table 1: Microbial isolates from different treatments

Treatments	Bacterial isolate	Fungal Isolate
CD	*Proteus sp, pseudomonas sp*and *Klebsiella aerogenosa.*	*Aspergillus niger Aurcobasidium sp,Cladosporium sp*and *Penicillium sp.*
SD	*Proteus sp, staphylococcus sp, klebsiella sp Streptococcus sp*and *E.coli,*	*Penicillium spp Cladosporium spp ,fusarium spp.*
PM	*Proteus sp, Bacillus sp, pseudomonas sp* and *E.coli*	*Penicillium sp, Aspergillus niger Cladosporium sp Penicillum sp,Fusarium sp and Aurcobasidium sp*
RMW	*Proteus sp,clostridium sp E,coli,Pseudomonas sp*and *Bacillus sp.*	*Cladosporium sp, peniccilum sp, Aspergillus niger*and *Fusarium sp*

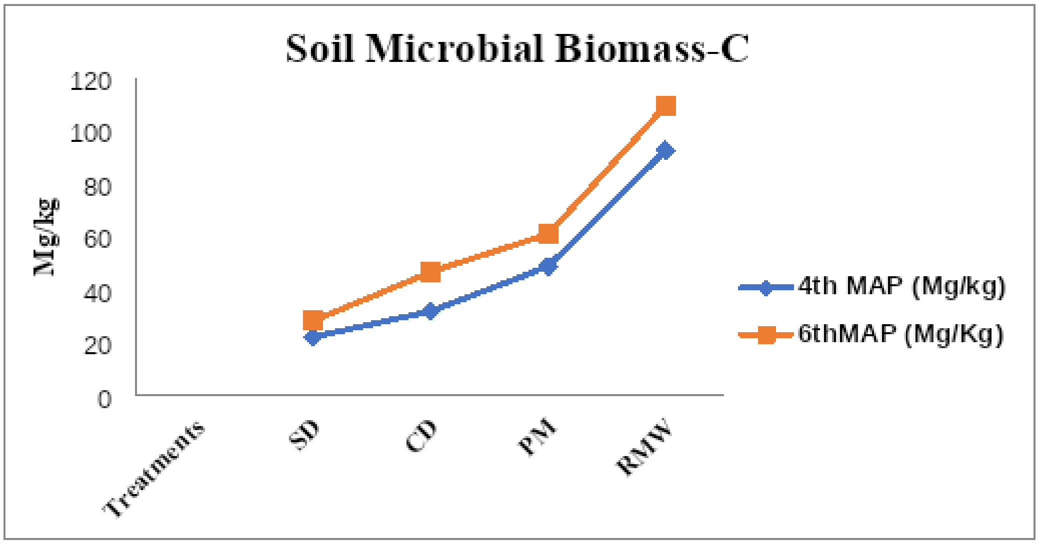

Fig 1: Microbial Biomass of Carbon (Mg/Kg) at 4th and 6th month after Planting.

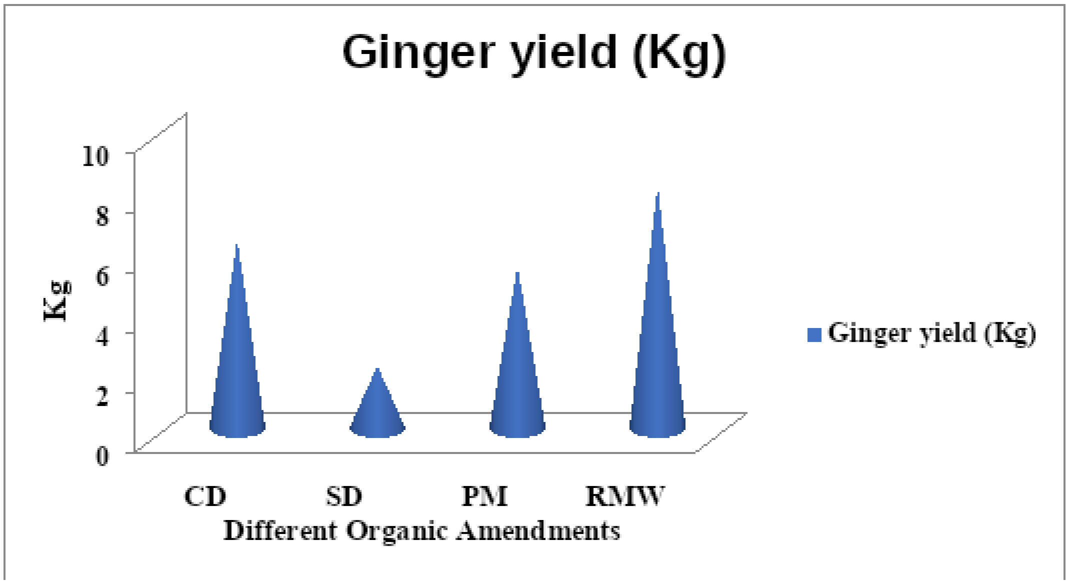

Fig2: Yield (Kg) Response after application of different organic amendment

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Spatiotemporal variation of Heavy metals in surface sediment of Mangroves Estuary, a multivariate analysis perspective, Badagry, Lagos, Nigeria

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ABSTRACT

Coastal ecosystems contribute significantly to marine primary productivity, and are responsibly a key player in the balance of the environment as they interrelate and interact dynamically. Mangroves are important ecosystem that functions ecologically and socio-economically at local to global scales. The concentration of internationally frightening five heavy metals (Cr, Cd, Pb, Ni, and Fe) was assessed the in surface sediment of Badagry creek in Lagos, Nigeria, during the dry and wet seasons from July 2017 to May 2019, Nine stations were established in the upper, middle and lower course of the creek, (upper; Ebute (Station 1), Gberefu (station 2), Topo (station 3), middle; Povita (station4), Ajido1 (station 5), Ajido2 (station 6), lower; Iworookun (station 7), Whispering palms1 (station 8) and Whispering palms2 (station 9). Heavy metals were analyzed by Atomic Absorption Spectrophotometer (AAS). The mean values of heavy metal concentration Chromium (Cr) 5.36±0.20, Lead (Pb) 6.24±0.3, Cadmium (Cd) 0.07±0.00, Nickel (Ni) 0.71±0.07, and Iron (Fe) 662±68.48, across the nine stations. varied significantly except Chromium, Nickel, and Iron which differed non-significantly. The concentration is in the following decreasing order FE>Pb>Cr>Ni>Cd. Seasonal variation of mean values differed non significantly, with higher values in the dry season than wet season registered for all the heavy metals. Total organic matter 7.06±0.42 (TOM) and Total organic carbon 4.10±0.44 (TOC) differed significantly across the stations. The correlation given values were Pb-Cr (r^2 =0.61), Cd-Cr (r^2 = 0.69), and TOC-Fe (r^2= 0.64), the results presented a moderate correlation between the heavy metal parameters suggesting similar non-point source pollution, such as domestic waste dumping, boat transportation activities,

sand dredging waste effluent and agriculture fertilizer runoff, while moderate correlation of Cd-Pb (r^2=0.43) suggested source origin from aquaculture industrial processing effluent. The principal component PC had 99.9% of the total variance of the heavy metal composition. The total variance of the PCs for heavy metal was 11.9%, 0%, and 0% for PC1, P,C2, and PC3 respectively. PC1 was only considered, the eigenvalues showed that there isa strong correlation with Fe (2.64), while Cr (-0.33), Pb (-0.33), Cd (-035), Ni (-0.34), TOM (-0.32) and TOC (-0.32) moderately correlated with PC1.

INTRODUCTION

Heavy metals among other hazardous chemicals have contributed large quantities of input globally into river due to exponential growth in human populaton, intensive domestic activities and through expansion of industry and agricultural production (Srebotnjak et al., 2021; Su et al., 2013; Islam et al., 2014; Islam ett al., 2015), Urban areas rivers usually have water quality problems because of the indiscriminate discharging of untreated domestic and industrial waste into the water bodies which gives entrance to the increase in the level of metals in river water (Khadse et al., 2008; Venugopal et al., 2009; Islam et al., 2015). Metals' behavior in the natural water form substrate sediment composition, the suspended sediment composition, and the water chemistry (Mohiuddin et al., 2012). In the process of water movement, heavy metals undergo several changes in speciation due to dissolution, precipitation, sorption, and complex procedure (Dassenakis et al., 1998; Akcay et al., 2003; Abdel-Ghani and Elchaghaby, 2007). Sediment is an important and unique part of the river and lagoon basin, with numerous diverse ecosystem. Mangrove aid the coastal food web, control the nutrient pollution, sequestrate carbon, form buffer zone against catastrophic emergent such as tsunamis, cyclone, hurricanes, can protect shoreline erosion, as habitat for terrestrial and marine fauna and flora (Sappal et al., 2016). The potential toxicity, accumulation and contamination of aquatic environment by heavy metal is matter of major concern (Jordan et al., 2014; Tscheikner-Gratl et al., 2019). Trace elements such as Uranium (U), arsenic (As), antimony (Sb), thorium (Th), beryllium (Be), radon (Rn), cadmium (Cd), selenium (Se), chlorine (Cl), phosphorus (P), chromium (Ch), Nickel (Ni), lead (Pb), mercury (Hg), manganese (Mn), and fluorine (F), and their compounds, are commonly found in coal and classified as potentially 'hazardous air pollutant' by the US Clean Air Act Amendments of 1990. The present study aims to evaluate the temporal seasonal variation of heavy metal in surface sediment samples of Badagry creek .

MATERIALS AND METHODS

The study focused on Badagry creek located south west, Lagos Nigeria. The creek is a long stretch of water body that runs parallel to the Atlantic Ocean in the south; it extends from Lake Nokue near Port-Novo, Benin republic to Apapa area of Lagos before opening up into the Atlantic Ocean via Lagos harbor. The creek (see Figure 3.1) is located in Lagos State, Nigeria between longitude 2º42ˈ and 3º23ˈE and latitude 6º23ˈand 6º 28ˈN. It is part of the 260km-long lagoon system stretching from Cotonou in the Republic of Benin to the Niger Delta in Nigeria. It is estimated to be more than 51km from Lagos. The creek is fed mainly by River Ajara in the Republic of Benin and the Yewa River in Nigeria while it also links Ologe Lagoon. Hundreds of villages, towns and commercial places like Marina jetty, coconut market, museum park, and point of no return jetty have been built on both side of the Badagry creek. Agriculture, aquaculture and fishing are the primary activities of the people living near the creek. This estuary creek receives domestic raw sewage, house hold waste, and industrial waste from surrounding habitat. Human activities over a period of have impacted the ecosystem of the creek.

Sample collection

Samples were collected from nine different stations (St1 – St 9; Ebute, Gberefu, Topo, Povita, Ajido1, Ajido2, Iworookun, Whisperingpalms1, and Whispering palms2) from upper, middle and downstream. The creek bed sediment samples were taken at a depth of 0 to 5cm using stainless steel VanVeen grab sampler. Sediment samples of mass approximately 250g were collected at each station. The collected sediments were air-dried at room temperature in the laboratory (Nigerian Institute for Oceanography and Marine Research). The dried samples were crushed to a fine texture in a ceramic mortar, re-packaged in labeled polythene bags. The sediment samples were analyzed for Cr, Cd, Pb, Ni, and Fe by the Atomic absorption spectrometry (AAS) (Model: is 3300,Thermo scientific).

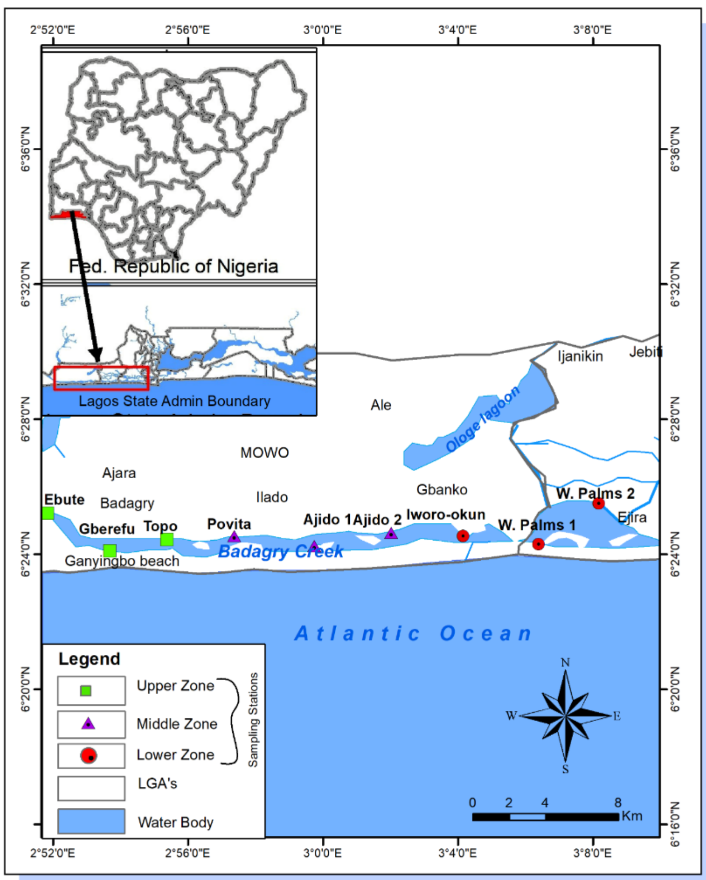

Fig 1: Map of Badagry Creek Showing Sampling Stations.

Data analysis

The data were statistically analyzed using the statistical package, SPSS 16.0 (SPSS, USA) and PAST v.3.2 (Hammar et al., 2001). The means and standard deviations of metal concentration were calculated. Pearson's correlation was applied to find the possible linear relationships among the different heavy metal in surface sediment samples. Agglomerative hierarchical clustering (AHC) was done by Ward's method with Euclidean distance as a measure of dissimilarity. Hierarchical clustering approach is generally used to found out the sequential clusters, grouping of similar objects and the step-by-step formation of the samples cluster (Maurya et al., 2019). Principal component analysis was performed on the data using correlation matrix.

RESULTS AND DISCUSSION

The mean values of heavy metal concentration (Table 1) Chromium (Cr) 5.36±0.20, Lead (Pb) 6.24±0.3, Cadmium (Cd) 0.07±0.00, Nickel (Ni) 0.71±0.07, and Iron (Fe) 662±68.48, across the nine stations (Ebute (station 1), Gberefu (station 2), Topo (station 3), Povita (station 4), Ajido1 (station 5), Ajido2 (station 6), Iworookun (station 7), Whispering Palms1 (station 8), Whispering Palms2 (station 9)) varied significantly except Chromium, Nickel and Iron that differed non significantly. The concentration is in the following decreasing order Fe>Pb>Cr>Ni>Cd. Seasonal variation of mean values presented in (Table 2) differed non significantly, with higher values in dry season than wet season registered for all the heavy metals. Total organic matter 7.06±0.42 (TOM) and Total organic carbon 4.10±0.44 (TOC) differed significantly across the stations. The mean range of Fe was between 26.40 and 4054mg/kg, this is similar to the value of Bhuyan et al., 2017 from Meghna river, Bangladesh. The highest Fe concentration was recorded in Ajido1(station 5) during the wet season in an impacted site of sand dredging and dredging waste discharge activities was present, this can be a reference to the dredging activities and runoff water from the neighboring location and the current mangrove vegetation at this station yield a enormous amount of litter that contribute to high Fe. The highest Pb concentration was (12.22mg/kg) in the aquaculture industrial zone during the dry season, the source of the discharge waste water of a shrimp processing plant and farm. This value is lower to Islam et al., 2015 reported range (36-83mg/kg) in Korotoa, Bangladesh, but Raphal et al., 2011 recorded a lower value of 0.45mg/kg from Okumeshi river, Nigeria. Cadmium concentration varied between (0.00 – 0.12), station 9 that is an aquaculture and shrimp processing plant, had the highest mean value during the wet season, this corroborates the result of Gupta et al., 2009 that reported (0.14-1.4) from river Ganges, India. Chromium maximum value was 9.12mg/kg registered at Povita (station 4) during the dry season, a station characterized under the activities of sand dredging, the value is lower to (55-183mg/kg) registered from Korotoa, Bangladesh, as stated from the findings of Islam et al., 2015. Nickel ranged between (0.17-3.80mg/kg), highest value in Ajido1 during the dry season, this result is similar to Raphal et al., 2011 that reiterated 1.21mg/kg from river Okumeshi , Nigeria. The station is impacted with non-point source of sand dredging and runoff of fertilizer from agriculture farm. TOM ranged between (0.10-33.37%) and TOC ranged (0.60-19.30%), highest percentage of TOM and TOC was recorded in Gberefu (station 2) during the wet season, with reference to domestic waste dumping, runoff water and transportation activities at this station.

Table 1: Heavy metal concentration variation across the nine stations

	St 1	St2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	P value
Chromium(mg/kg)	3.48±0.60^{a}	4.41±0.54^{ab}	6.00±0.65^{b}	6.03±0.71^{b}	4.87±0.59^{ab}	5.89±0.53^{b}	5.45±0.69^{b}	5.95±0.60^{b}	6.21±0.37^{b}	P>0.05
Lead(mg/kg)	3.69±.330^{ab}	3.39±0.37^{a}	6.34±1.08^{bc}	6.96±1.18^{c}	6.25±1.00^{bc}	6.16±1.11^{bc}	5.94±0.94^{ac}	9.55±0.35^{bc}	7.91±1.03^{bc}	P<0.05
Cadmium(mg/kg)	0.03±0.00^{a}	0.03±0.00^{a}	0.09±.00^{b}	0.07±0.01^{b}	0.07±0.01^{b}	0.07±0.01^{b}	0.07±0.01^{b}	0.11±0.01^{c}	0.13±0.01^{c}	P<0.05
Nickel(mg/kg)	0.85±0.29^{a}	1.12±0.36^{a}	0.45±0.03^{a}	0.71±0.21^{a}	1.16±0.41^{a}	0.44±0.10^{a}	0.48±0.10^{a}	0.64±0.09^{a}	0.59±0.08^{a}	p>0.05
Iron(mg/kg)	923.87±291.28^{ab}	939.47±280.88^{ab}	441.09±45.82^{ab}	636.20±167.69^{ab}	1069.94±379.19^{b}	424.72±80.39^{ab}	390.96±75.20^{a}	577.63±83.01^{ab}	561.91±87.32^{ab}	p>0.05
TOM (%)	9.64±0.76^{c}	27.21±1.35^{d}	4.48±0.67^{b}	3.75±0.68^{ab}	4.0784±0.97^{ab}	3.43±0.69^{ab}	1.92±0.19^{a}	4.57±0.49^{b}	4.56±0.76^{b}	P<0.05
TOC(%)	5.49±0.42^{c}	15.90±.80^{d}	2.61±0.39^{ab}	2.18±0.39^{ab}	2.36±0.56^{ab}	2.00±.40^{ab}	1.12±0.11^{a}	2.64±.28^{b}	2.64±0.44^{b}	P<0.05

Table 2: Seasonal Variation of Heavy metal concentration, Dry and Wet seasons

	DRY	WET	P VALUE
Chromium(mg/kg)	8.33±2.05	7.75±1.44	p>0.05
Lead(mg/kg)	9.40±4.45	9.32±3.75	p>0.05
Cadmium(mg/kg)	0.12±0.01	0.01±0.00	p>0.05
Nickel(mg/kg)	1.09±0.37	1.05±0.35	p>0.05
Iron(mg/kg)	1020.27±293	968.16±310	p>0.05
TOM (%)	10.68±0.38	10.52±0.75	p>0.05
TOC (%)	6.21±0.24	6.10±0.44	p>0.05

Correlation

The correlation matrix expressed the strength of relationship between the investigated heavy metal parameters (Gopinath et al., 2019). The given values were positively moderate correlated (Liu et al., 2020), Pb-Cr (r^2 =0.61), Cd-Cr (r^2 = 0.69), TOC-Fe (r^2= 0.64), suggest similar non point source pollution, such as domestic waste dumping, boat transportation activities, sand dredging waste effluent and agriculture fertilizer runoff, while moderate correlation of Cd-Pb (r^2=0.43) suggested source origin from aquaculture industrial processing effluent.

Table 3: Correlation matrix between the heavy metal parameters in the sediment sample

	Chromium	Lead	Cadmium	Nickel	Iron	TOM	TOC
Chromium							
Lead	.603*						
Cadmium	.691*	.433*					
Nickel	-0.368	-.941**	0.254				
Iron	-0.482	-.915**	0.300	.961**			
TOM	-.168	-0.305	-.029	-.461**	-.640*		
TOC	-.159	-0.314	-.016	-.472	.645*	.997**	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

Multivariate Analysis

Cluster analysis

The hierarchical analysis of all the nine sampling stations clustered into two groups according to their similarities. Cluster 1 and 2 had 3 and 6 stations respectively. cluster 1(Ebute (station 1), Gberefu (station 2), Ajido 1(station 5)), while cluster 2 had (Topo (station 3), Povita (station 4), Ajido 2(station 6), Iworookun (station 7) Whispering palms1(station 8) and Whispering palms2 (station 9)). Each cluster represents a distinguish feature which shows the heavy metal chemical progression taking place in the surface sediment of the estuary and impact of the land use activities. Cluster 1 had stations grouped under domestic waste, boat transportation and sand dredging activities with high loadings of TOM,TOC, Fe and Ni. Cluster 2 comprising of major factors of Fe, Pb, Cd and Ni with sampling stations characterized with anthropogenic activities.

Principal Component Analysis

The extracted method, correlation matrix was executed, the components were taken as principal components whose eigen values were greater than 1 were taken into account. 3 PCs were extracted which reflects the process influencing the heavy metal composition having 99.9% of total variance (Table 4). The total variance of the PCs for heavy metal was 11.9%, 0%, and 0% for PC1,PC2 and

PC3 respectively. PC1 was only considered, the eigen values showed that there is strong correlation with Fe (2.64), while Cr (-0.33), Pb (-0.33), Cd (-035), Ni (-0.34), TOM (-0.32) and TOC (-0.32) moderately correlated with PC1. The source of PC1 can be reference to the same source from anthropogenic inputs. The PC1, PC2, and PC3 extracted for the sampling months had 86% composition of the total variance of the sampling months of total variance of PCs were 48.13%, 21.20% and 17.38% for PC1, PC2, and PC3 respectively. Principal components whose eigen values were higher than 0.6. PC1 strongly correlated with March ’18, March’19, May ’19, May ’19, July ’18, September ’18, November ’18 and January ’19. The strong correlation of the wet season months indicated massive input of runoff water from agriculture fertilizer farm, domestic dumping, and aquaculture waste effluent. The sampling stations had PC total composition variance of 96.13%, PC1 was considered with variance 70.13%, eigen values higher than 0.5 were considered. The eigen values presented (Table 4), Ebute (1.17), Gberefu (1.97), and Ajido1(0.54) strongly associated with PC1, while Topo (-0.62), Ajido2 (-0.54), Whispering palms1(-0.82) and Whispering palms2(-0.86) negatively associated with PC1. Station 4 and 7 (-0.36 and -0.48) weakly correlated with PC1.

Table 4: Component matrix of three factors model with strong to moderate loadings in sediment

Variables	PC1	PC2	PC3
Chromium	-0.33	**0.44**	**-0.93**
Lead	-0.33	**1.54**	**-1.53**
Cadmium	-0.35	**-1.48**	-0.43
Nickel	-0.34	**-1.53**	-0.27
Iron	**2.66**	-0.01	-0.01
Total organic matter (TOM)	-0.32	**0.93**	1.89
Total organic carbon (TOC)	-0.33	-0.09	0.94
July_17	**-0.59**	**1.02**	-0.19
Sept_17	**-0.51**	**1.18**	0.20
Nov_17	**-0.59**	**0.83**	0.42
Jan_18	**-0.51**	**0.95**	0.48
Mar_18	**-0.70**	-0.13	-0.19
May_18	**-0.84**	**-1.31**	-0.34
July_18	**1.81**	**1.16**	-0.91
Sept_18	**0.73**	**-1.32**	0.27
Nov_18	**1.38**	-0.48	2.50
Jan_19	**1.31**	-0.48	-1.76
Mar_19	**-0.67**	-0.12	-0.14
May_19	**-0.82**	**-1.29**	-0.34
Ebute (Station_1)	**1.17**	-0.47	-1.40
Gberefu (Station_2)	**1.97**	-0.23	1.70
Topo (Station_3)	**-0.62**	**-0.75**	0.30
Povita (Station_4)	-0.36	0.20	-0.13

AjidoSt_5	**0.54**	**1.73**	-1.24
AjidoSt_6	**-0.54**	**-1.08**	-0.13
IworookunSt_7	**-0.48**	**-1.16**	-0.59
WhisperingpalmsSt_8	**-0.82**	**1.03**	0.67
WhisperingpalmsSt_9	**-0.86**	**0.73**	0.83
% Total variance Heavy metal	11.9	0.00	0.00
Cumulative % Heavy metal	99.9	0	0
% Total variance Months	4.33	1.90	1.56
Cumulative % Months	48.13	21.2	17.38
% Total variance Stations	4.9	0.97	0.87
Cumulative % Stations	70.13	13.96	12.51

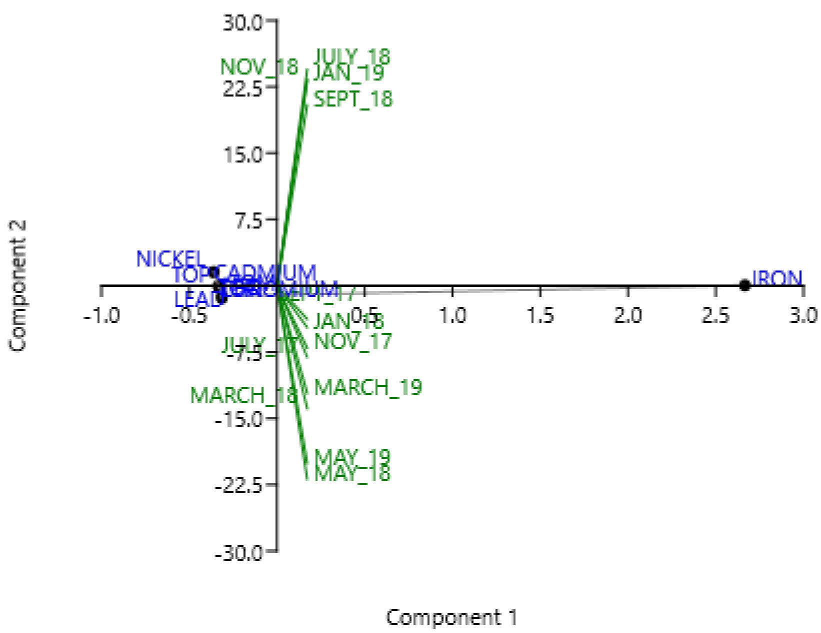

Figure 2: Biplot demonstrating factor loadings of the two principal components and related distribution of sampling months

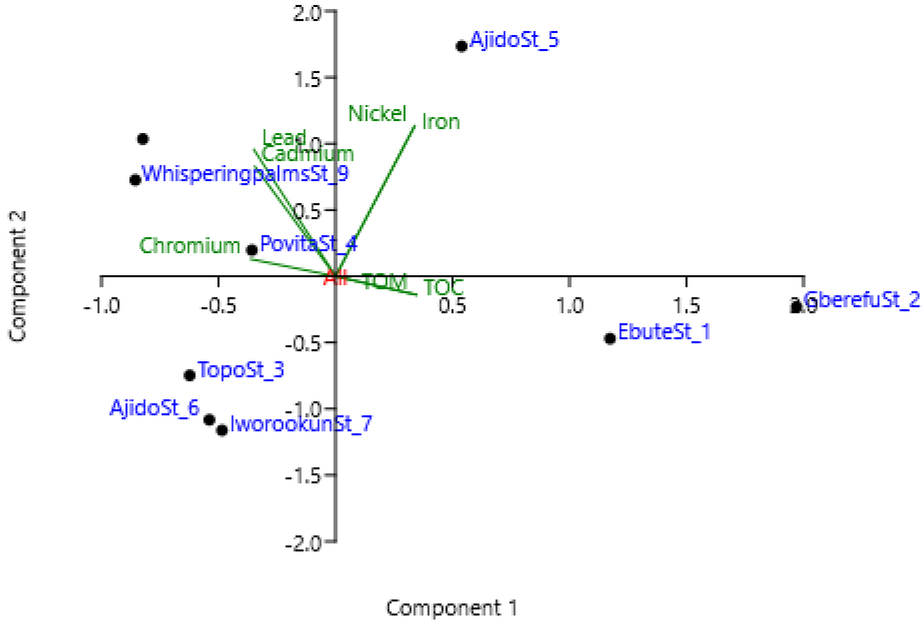

Figure 3: Biplot demonstrating factor loadings of the two principal components and related distribution of sampling stations

Figure 4: Dendrogram showing agglomerative hierarchical clustering for different sampling stations.

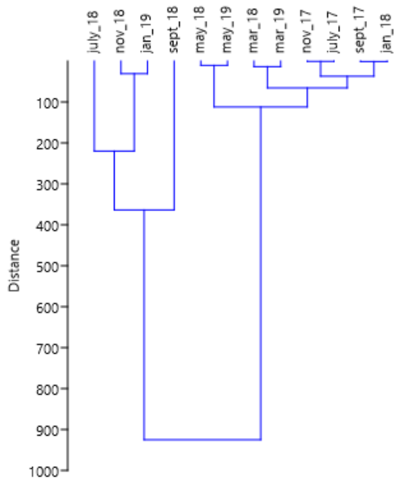

Figure 5: Dendrogram showing agglomerative hierarchical clustering for different sampling months.

Canonical Correspondence Analysis

The first two axes explained that 100% of the variance of heavy metal concentration in surface sediment can be explained by the sampling months (period of collection). The CCA ordination bi-plot diagram (figure 6) indicated the eigen values of Cr (0.28), Pb (0.77), Cd (0.52), Ni (0.1), Fe (-0.03), TOM (0.78) and TOC (0.71) were strongly associated with the sampling months, except Iron and Nickel that had weak correlation. Secondly, figure 7 , explained that 100% of the first two axes of the variance of heavy metal concentration can be related to the sampling stations, (station 1 – Station 9). The eigen scores were Cd (0.32), Ni (0.00), Fe (0.0), TOM (0.49), TOC (0.5), Cr (-0.4) and Pb (0.58), it showed that all parameters had moderate association with the stations, while Ni and Fe had weak correlation. All the parameters had moderate influence in all the stations except in Ebute (station 1), this is an indication of different sources of pollution input from the human activities, runoff water of agriculture fertilizer, domestic waste dumping, sewage, sand dredging waste water, and aquaculture shrimp processing plant in all the stations. Ebute (station 1) is located at the upper course of the creek received direct waste and sewage dumping from the municipal.

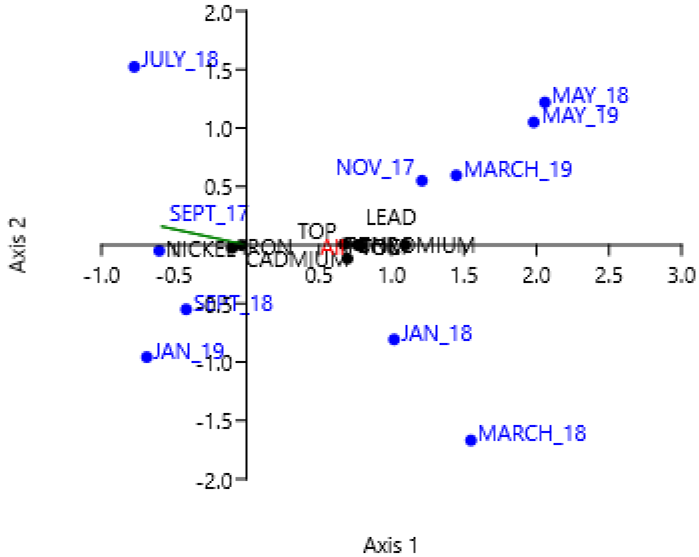

Figure 6: Canonical Correspondence Analysis of loadings of heavy metal among the sampling months

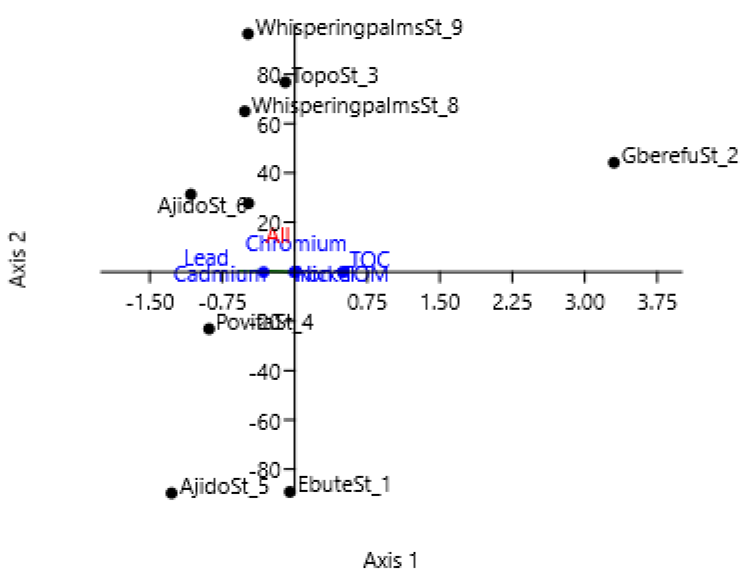

Figure 7: Canonical Correspondence Analysis of the loading plots of heavy metals across the sampling stations

CONCLUSION

The present study summarizes the variation in heavy metal concentration in Badagry creek. The canonical correspondence analysis, Algometric hierarchical cluster and Principal component present the sampling locations with similar characteristics evolved in the same group reflecting on the source and origin. The high concentration of Fe is reference to the dominance of inherent biological productivity and redox processes at the sediment surface water. Agricultural runoff, sand dredging waste water , aquaculture waste, domestic waste dumping and shrimp processing plant waste were the major source of Pb, Cd, Cr, and Ni.

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Soil fertility and Sugarcane (*Saccharum officinarum* L.) productivity under trash mulch rate and weed management practice in Nigeria

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ABSTRACT:

Yield decline is an issue that has plagued sugarcane production in Nigeria. The objective of the study was to evaluate the effects of sugarcane trash mulch and weed management practices on soil fertility and sugarcane production. Field experiment was conducted in 2016 and 2017 at National Cereals Research Institute, Badeggi in the Southern Guinea Savanna ecology of Nigeria. The treatments consisted of factorial combination of two sugarcane genotypes (Bida local and NCS 001), four sugarcane trash mulching levels (0, 3, 6, 9 t/ha) and four weed management practices (weedy check, 5 monthly hoe weeding (5MHW), pre-emergence (PE) application of diuron at 2 kg a.i/ha + Post-Emergence (POE) of 3-Maize force at 179.2 g/ha + Two hoe weeding (2HW)] and PE Diuron + POE 3-Maize force arranged in a split plot design and replicated three times. Weed management practices and mulching constitute the main plot while sugarcane genotypes constitute the subplot. The results showed that application of 9 t ha^{-1} trash mulch significantly ($P<0.05$) produced the highest organic carbon, N, P and K, which in turn enhanced sugarcane yield. Similarly, the application of 9 t ha^{-1} trash mulch plus PE+POE+ 2HW produced the highest NCS 001 sugarcane yield. In conclusion, application of trash mulching at 9 t ha^{-1} plus P.E+PO.E+ 2HW effectively boast soil fertility and sustained the productivity of NCS 001 sugarcane in the study area and related ecologies.

Keywords: Sugarcane, Trash mulch, Soil properties, Genotypes, Weed management

INTRODUCTION:

Sugarcane (*Saccharum officinarum* L.) is a significant commercial cash crop widely grown by farmers in most tropical countries grown for the production of sugar, molasses, livestock feeds, alcohol, bagasses for fuel (Alvaris, 2008; Junejo *et al.*, 2010), and trash for mulching and as organic fertilizer (Gana, 2008). Sugarcane contributes 60 % of the total world sugar requirement, while the remaining 40 % comes from sugar beet (Busari and Misari, 2007). Weeds constitute a significant component of the pest complex in African farms and form an important constraint in agricultural production system in most farmers' fields (Takim and Amodu, 2013). Apart from the quantitative damages caused by weeds to crops due to competition for water, light and nutrients, weeds can cause a reduction in crop yield (Takim *et al*., 2012). Previous studies have shown a reduction in sugarcane yield due to weed infestation by 40 - 67% (Ndarubu *et al*., 2006; Kadam *et al*., 2011). There is an urgent need to integrate these weed management options with trash mulching for weed control and boost the production of these sugarcane genotypes in order to meet the needs of increasing population. Hence, the objective of the study was to evaluate the effect of varying trash mulch and weed management practices on soil properties sugarcane genotypes production in this study area.

MATERIALS AND METHODS:

Field trial was conducted at the upland sugarcane experimental field of the National Cereals Research Institute, Badeggi (lat. 9^0 45^1 N, long. 0.6^0 07^1 E) in the Southern Guinea savanna agro-ecological zone of Nigeria in 2016 and 2017 rainy season. At the commencement of the experiment, a composite sample from ten random points was collected, using a soil auger at 0 - 15 cm depth for both years. The initial soil properties of the experimental site are shown in Table 1. The total rainfall during the experimental period was 1504.1 mm in 2016 and 1045.4 mm in 2017, respectively. The mean air temperature during the sugarcane plant cropping season was 35 to 38 ^oC in 2016 and 34 to 36 ^oC in 2017 plant cropping seasons. Prior to cultivation, the vegetative cover of the experimental site was manually cleared, ploughed and harrowed with a tractor. Tender healthy young stalks of six months old sugarcane were used as planting material. The stalks were cut into setts each containing three eye buds. The PE diuron was applied a day after planting at the rate of 2.0 kg a.i/ha while the POE 3-Maize force was applied at five weeks after planting (WAP) at rate of 179.2g a.i/ha. The weeds were identified using the hand book of West African Weeds (Akobundu *et al*., 2016). NPK fertilizer was applied at 150 kg N, 60 Kg P and 90 Kg K in equal halves at planting and 8 – 10 WAP. The treatments consists of factorial combination of two sugarcane genotypes, Bida local and NCS 001, four cane trash mulching levels, (0, 3, 6, 9 t ha^{-1}) and four weed management practices (weedy check, 5 monthly hoe weeding (5MHW), Pre-emergence of diuron at 2 kg a.i/ha (PE) + Post-Emergence(POE) 3-Maize force at 179.2 g/ha + Two hoe weeding (2HW)] and PE diuron + POE 3-Maize force arranged as a split plot and replicated three times. Herbicides were applied with knapsack (CP3) sprayer at a spray volume of 4l/ha. Weed management practices and mulching were allocated in the main plot while sugarcane genotypes in the subplot. The gross plot size was 35 m^2 (7 m x 5 m), while the net plot size was 17.5 m^2 (3.5 m x 5 m). Each net plot consists of four rows of 5 m long. All data collected were subjected to analysis of variance (ANOVA). The means were separated using Duncan multiple range test at 5 % level of probability using SAS version 9.0 statistical package.

RESULTS AND DISCUSSIONS:

Sugarcane genotypes was significantly (P<0.05) influenced by organic carbon and total nitrogen at harvest (Table 2). Industrial sugarcane recorded the highest organic carbon and nitrogen than the local chewing cane. The application of 9 t ha^{-1} trash mulch significantly (P<0.05) produced the highest organic carbon, N, P and K which was closely similar to 6 and 3 t ha^{-1}. The result shows the ability of trash mulch in increasing soil organic matter, N (Graham and Haynes 2005; Robertson and Thorburn 2007; Yadav *et al*. 2009; Fortes *et al*. 2012) and improved physico-chemical properties. Similarly, organic carbon, N, P and K, were significantly (P<0.05) influenced by weed management practices (Table 2). The application of Pre-emergence + Post-emergence herbicide produced the highest organic carbon, N, P and K.

Table 1 Initial soil physical and chemical properties in 2016 and 2017 at Badeggi

Parameter	2016 Site	2017 Site
Sand (g kg^{-1})	722	765
Silt (g kg^{-1})	135	156
Clay (g kg^{-1})	143	79
Textural class	Sandy loam	Sandy loam
pH (H_2O) (g kg^{-1})	5.80	6.40
Organic Carbon (g kg^{-1})	2.37	3.45
Total Nitrogen (g kg^{-1})	0.06	0.33
Available Phosphorus(mg kg^{-1})	20.29	23.15
Ca++ (cmol kg^{-1})	2.48	4.18
Mg++ (cmol kg^{-1})	1.38	3.68
K+ (cmol kg^{-1})	0.16	0.30
Na+ (cmol kg^{-1})	0.09	0.22
Exchangeable acidity(cmol kg^{-1})	1.03	1.07
ECEC (cmol kg^{-1})	5.14	9.45

Analysed at National Cereals Research Institute Laboratory

Table 2: Effects of sugarcane genotypes and weed management practices on same soil properties at 12 MAP in 2016 and 2017 seasons

Treatments	Soil properties: Organic C (g kg^{-1}) 2016	2017	Total N (g kg^{-1}) 2016	2017	Available P (mg kg^{-1}) 2016	2017	Potassium (cmol kg^{-1}) 2016	2017
Genotypes (S)								
Bida local	40.47	43.34	0.30	0.38	138.95	158.19	2.97	3.27
NCS 001	40.49	43.36	0.31	0.39	173.61	187.42	2.58	2.68
LSD (0.05)	0.005	0.007	0.02	0.005	12.16	11.37	0.13	0.11
Mulching (M)								
0	40.33	43.19	0.20	0.31	123.09	156.04	2.09	2.65
3	40.44	43.31	0.26	0.32	157.18	167.92	2.90	2.97
6	40.54	43.38	0.34	0.39	161.36	171.5b	2.93	3.01
9	40.63	43.54	0.43	0.51	183.48	195.75	3.16	3.28
LSD (0.05)	0.009	0.008	0.004	0.004	17.19	16.08	0.19	0.16
Weed management								
Weedy check	40.36	43.32	0.28	0.36	123.62	156.92	2.10	2.66
MHW	40.48	43.34	0.30	0.37	181.46	191.79	3.15	3.24
PE +POE+ 2HW	40.49	43.33	0.32	0.39	161.35	171.96	2.93	2.99
PE + POE	40.50	43.42	0.33	0.41	158.69	170.54	2.91	3.24
LSD (0.05)	0.01	0.006	0.005	0.004	17.19	16.08	0.19	0.16
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

LSD- least significant difference, MHW-Monthly hoe weeding, PE- Pre-emergence (Diuron at 2 kg a.i/ha) herbicide, POE- Post-Emergence (3-Maize force at 179.2 g/ha) herbicide, NS-Not significant, MAP- Months after planting

Sugarcane genotypes was significantly (P<0.05) influenced by stalk height at 11 MAP (Table 3). Industrial sugarcane recorded the highest stalk height than the local chewing cane. The advantage that industrial sugarcane has over local chewing cane in stalk height can be attributed to the ability of industrial sugarcane to withstand drought more than the chewing sugarcane. This result confirms the findings of Ishaq and Olaoye (2007) which states that industrial sugarcane establishes faster because of its ability to withstand drought than the chewing cane. Similarly, stalk height at 11 MAP was significantly influenced by different rates of trash mulch application. The application of 9 t ha^{-1} trash mulch significantly (P<0.05) produced the highest stalk height which was closely similar to 6 and 3 t ha^{-1}. The result shows the ability of trash mulch in enhancing growth parameter, which may be attributed to increased soil organic matter (Graham and Haynes 2005; Robertson and Thorburn 2007; Yadav *et al*. 2009; Fortes *et al*. 2012), improved physico-chemical properties and soil water regimes. Cheong and Teeluck (2015) indicated that unburned trash remaining as surface mulch resulted in annual recycling of 105 kg N ha^{-1} therefore complement fertilizer needs. Stalk height at 11 MAP was significantly (P<0.05) affected by weed management practices (Table

3). Stalk height was highest with the application of Monthly hoe weeding which was similar to Pre-emergence + Post-emergence herbicide + 2 hoe weeding and application of Pre-emergence + Post-emergence herbicide only. The result of this study demonstrates the effectiveness of manual weeding, Pre-emergence + Post-emergence herbicide application in influencing growth parameter. Our results are consistent with previous studies of Smith *et al*.(2008) and Zafar *et al*. (2010) which indicates that growth parameters in sugarcane can be achieved by mechanical, chemical and chemical + mechanical and trash mulching.

Sugarcane genotypes significantly influenced stalk girth at 10 MAP (Table 3). The local chewing cane recorded the highest stalk girth than the industrial sugarcane. The superiority of the local chewing cane in having higher stalk girth than the industrial can be attributed to more robust, soft stem with high water and less sucrose content. This confirms the finding of Busari *et al*. (2005) which states that local chewing canes has more robust, soft stem with high water and less sucross than the industrial canes. Similarly, stalk girth at 10 MAP was influenced by different rates of trash mulch applied. The application of 9 t ha^{-1} trash mulch produced significant ($P<0.05$) higher stalk girth which was similar 6 and 3 t ha^{-1}. This may be attributed to high moisture retention, increased soil organic matter and improved physico-chemical properties like N and S (Robertson and Thorburn 2007; Yadav *et al*. 2009 and Gana (2008). Stalk girth at 10 MAP was also affected by weed management practices (Table 2). Stalk girth was highest with the application of monthly hoe weeding which was similar to Pre-emergence + Post-emergence herbicide + 2 hoe weeding and application of Pre-emergence + Post-emergence herbicide only. Our result was consistent with previous studies conducted by Smith *et al*.,(2008) and Zafar *et al*.(2010) which reported that the application of monthly hoe weeding followed by Pre-emergence + Post-emergence herbicide + 2 hoe weeding recorded an increase in sugarcane girth compared to the check plot.

Sugarcane genotypes significantly influenced brix at 11 MAP (Table 3). Industrial sugarcane recorded the highest brix than the local chewing cane. This may be due to the fact that industrial sugarcane has relatively thin and hard stem, thick ring (nodes) and usually contains more sucrose and less water content. This confirms the findings of Busari *et al*.(2005) and Shah *et al*. (2008) which states that improved sugarcane (industrial canes) variety usually have thin stems with high sucrose content and less water due to their varied genetic potential of sugarcane genotypes. Similarly, sugarcane brix at 11 MAP was significantly ($P<0.05$) influenced by different rates of trash mulch application. The application of 9 t ha^{-1} trash mulch produced significant ($P<0.05$) higher brix which was closely similar to 6 and 3 t ha^{-1}. This result may be attributed to the response of improved variety to higher moisture conservation, weed suppression potentials and increased N availability of trash mulch. This is in agreement with the finding of Thompson (2005); Uwah and Iwo, 2011). Brix at 11MAP was significantly affected by weed management practices (Table 3). Brix was highest with the application of monthly hoe weeding which was similar to Pre-emergence + Post-emergence herbicide + 2 hoe weeding and application of Pre-emergence + Post-emergence herbicide only. This may be attributed to effective weed control which resulted in increasing yield promoting attributes. Our result is in agreement with the previous findings of Smith *et al*., (2008) and Singh *et al*. (2011) which reported that all the weed control treatments favourably influenced the yield contributing characters such as stalk height, stalk girth and brix. Sugarcane genotypes significantly influenced sugarcane yield at harvest (Table 3). Industrial sugarcane recorded the highest yield than the local chewing cane. The difference in cane yield of sugarcane genotypes was due to their varied genetic potential which exploit edaphic and aerial factors of crop production. These results are in accordance with those of Bashir *et al*. (2012), Ongin *et al.* (2011) and Shah *et. al.* (2008) who reported significant difference among the sugarcane genotypes for cane tonnage. Similarly, sugarcane yield at harvest was significantly influenced by different rates of trash mulch application. The application of 9 t ha^{-1} trash mulch produced significantly ($P<0.05$) highest yield which was statistically similar to 6 and 3 t ha^{-1} in 2016. However, in 2017, application of 3 t ha^{-1} of sugarcane trash produced the highest yield; statistically similar results were obtained in 6 and 9 t ha^{-1} while the lowest yield was obtained in the control plot. The result is similar to the findings of Srivastava and Chauhan (2006) and Gana (2008) which states that the higher the quantity of organic mulch applied, the more the productivity of the crop on the field. Sugarcane yield at harvest was significantly ($P<0.05$) affected by weed management practices (Table 3). Yield was highest with the application of monthly hoe weeding which was similar to Pre-emergence + Post-emergence herbicide + 2 hoe weeding and application of Pre-emergence + Post-emergence herbicide only in 2016. But in 2017, application of Pre-emergence + Post-emergence herbicide gave the highest yield which was in turn similar to the application of monthly hoe weeding and Pre-emergence + Post-emergence herbicide + 2 hoe weeding .This may be attributed to effective weed control which resulted in increasing yield. The result is in agreement with the findings of Singh *et al*. (2011) who observed that increased number of stalk height, stalk girth and cane yield was observed with weed free situations. Sugarcane genotypes responded positively to trash mulching and weed management practices. Industrial cane (NCS 001) performed better than Bida local in terms of growth establishment, yield and weed suppression. Response to trash mulching from 6- 9 t ha^{-1} contributed significantly in high yield of sugarcane.

Table 3: Effects of sugarcane genotypes and weed management practices on stalk height, Girth, Brix content, Number of Stool per plot , Millable stalks and Came yield at 12 MAP

	Stalk height (cm)		Stalk girth (cm)		Brix content (%)		Number of Stool per plot		Millable stalks per stool		Cane yield (t ha^{-1})	
Treatment	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Genotypes (S)												
Bida local	146.4	172.5	3.05	3.27	16.49	16.74	9.17	17.63	3.01	3.29	52.12	57.24
NCS 001	178.6	201.9	2.63	2.68	18.28	18.29	11.75	22.17	5.51	5.33	82.27	66.18
LSD (0.05)	11.05	33.65	0.12	0.11	0.62	0.58	1.27	1.47	0.52	0.40	4.63	4.61
Weed management (W)												
Weedy check	148.5	168.7	2.37	2.66	16.60	16.30	8.17	14.67	3.63	3.75	57.33	54.91
5 MHW	181.5	209.1	3.15	3.24	18.15	18.38	11.79	20.83	4.63	4.63	77.54	61.29
PE +POE+ 2MHW	161.4	186.0	2.93	2.99	17.11	17.38	10.46	21.88	4.35	4.29	66.08	63.76
PE + POE	158.7	184.9	2.91	3.24	17.68	18.0	11.42	22.21	4.43	4.58	67.81	66.87
LSD (0.05)	15.63	20.03	0.17	0.16	1.29	0.82	1.79	2.09	0.73	0.57	8.36	5.23
Interaction												
S x W	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

in 2016 and 2017 seasons

LSD - least significant difference, MHW-Monthly hoe weeding, PE- Pre-emergence (Diuron at 2 kg a.i/ha) herbicide, POE- Post-Emergence (3-Maize force at 179.2 g/ha) herbicide, NS-Not significant

CONCLUSION:

The application of 9 t ha^{-1} trash mulch produced the highest organic carbon, N, P and K. Increased trash mulching of 9 t ha^{-1} with application of P.E+PO.E+ Two hoe weeding was promising in managing weeds thus, sustaining the productivity of sugarcane.

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Correlation Coefficient Between Sugarcane Yield And Some Weed, Growth And Soil Properties For Sugarcane Genotypes At Badeggi

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ABSTRACT

In the present study, correlation analyses of data collected on agronomic characters were used to determine the relationship of these characters with cane yield; and ascertain their contribution in obtaining high cane yield. Field experiment was conducted in 2016 and 2017 at National Cereals Research Institute, Badeggi in the Southern Guinea Savanna ecology of Nigeria. The treatments consisted of factorial combination of two sugarcane genotypes (Bida local and NCS 001), four sugarcane trash mulching levels (0, 3, 6, 9 t/ha) and four weed management practices (weedy check, 5 monthly hoe weeding (5MHW), pre-emergence (PE) application of diuron at 2 kg a.i/ha + Post-Emergence (POE) of 3-Maize force at 179.2 g/ha + Two hoe weeding (2HW)] and PE Diuron + POE 3-Maize force arranged in a split plot design and replicated three times. Weed management practices and mulching constitute the main plot while sugarcane genotypes constitute the subplot. The cane yield, considered as the most important character of sugarcane, was positively and significantly correlated with sprouting percentage (r=0.531**), number of tillers (r=0.574**), number of millable canes (r=0.716**), sugarcane stalk girth (r=0.595**) and height (r=0.677**), sugarcane brix (r=0.595**), organic carbon (r=0.568**), nitrogen (r=0.532**) and soil moisture content (r=0.531**) while Phosphorus (r=0.445), Potassium (r=0.397), showed positive but non-significant correlation with cane yield. Cane yield was negatively correlated with evapotranspiration (r= -0.500) and weed dry matter (r= -0.556) at all the stages. Results from the analysis indicated that selection programme for high yielding sugarcane genotypes should be based on sprouting percentage, number of tillers, number of millable canes, sugarcane stalk girth and height, sugarcane brix, organic carbon, nitrogen and soil moisture content.

Keywords: Sugarcane, Correlation, Growth, Yield, Attributes

INTRODUCTION

Sugarcane (*Saccharum* spp.) belongs to the family Poaceae, which are large tropical or subtropical grasses that are grown widely within the zone of 30^{o} C on either side of the equator (Wada *et al.*, 2017). Approximately, 75 % of world's sucrose production is from sugarcane (Bassey *et al.*, 2020). Besides the production of raw sugar, of which sugarcane is mainly produced for, sugarcane also represents an important source of renewable energy which has recently gained attention because of ethanol production. The national average yield of sugarcane is less than 65 t ha $^{-1}$ which is much lower than the world average of 175.1 t ha $^{-1}$ (NSDC, 2014). The correlation between growth and yield components of sugarcane has been studied and reported by several authors. Sanjay and Devendra (2014) reported that, sugarcane yield was significantly and positively correlated with germination percentage, number of shoots, number of millable canes, stalk diameter, stalk length, number of internodes, length of internodes, stalk weight, number of green leaves, while with the top weight, it showed positive but non-significant correlation. Cane yield was negatively correlated with brix at all the stages. In the present study, correlation analyses of data collected on agronomic, soil and weed parameters on sugarcane genotypes were used to determine the relationship of these characters with cane yield and ascertain their contribution in obtaining high cane yield at Badeggi, Nigeria.

MATERIALS AND METHODS

A field experiment was conducted at the upland sugarcane experimental field of National Cereals Research Institute, Badeggi (Lat. 9^{0} 45' N, Long. 6^{0} 07' E and 89 m above sea level) in the southern Guinea savanna agro-ecological zone of Nigeria in 2016 and 2017 wet and dry season. The average annual rainfall during the experimental was 1504.1mm in 2016 and 1045.4 mm in 2017 while the mean air temperature was 35 to 38 ^{0}C in 2016 and 34 to 36 ^{0}C in 2017.

Composite soil samples were taken before field establishment from ten spots along a diagonal and at harvest from each treatment plot from 0 to 15 cm depth, and subjected to routine analyses. Particle size analysis was done by the Bouyoucos hydrometer method (Gee and Or 2002). Soil organic carbon was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson *et al*. 1996). Total N was determined by the micro—Kjeldahl digestion method (Bremner and Mulvaney 1982). The Olsen method was used to determine available phosphorus, and flame photometry for exchangeable potassium (Okalebo *et al*. 2002).
Soil pH was determined in 1:2 soil–water ratio using digital electronic pH meter.

Before cultivation, the vegetative cover of the experimental site was manually cleared, ploughed and harrowed with a tractor in the first week of February 2016 and 2017. The land was fully irrigated before planting by pumping water from a stream using a 3.5 HP water pump with a 12.5 cm diameter hose. Thereafter, the land was marked out into plots with bunds at the edges for water retention. Gross plot size was 5 m x 4 m (20 m^{2}) consisting of 4 sugarcane rows, and net plot size was 5 m x 2 m (10 m^{2}) consisting of 2 sugarcane rows. Each row was spaced at 1 m apart. Tender healthy young stalks of six months old sugarcane were used as planting material. The stalks were cut into setts each containing three eye buds, planted continuously end-to-end without intra-row spacing in shallow sunken bed. The application of pre-emergence (PE) diuron was done immediately after planting at 2.0 kg a.i ha-^{1}. The trash mulch was applied at a thickness of 1, 3 and

5 cm (Henrique *et al*. 2013) for 3, 6 and 9 t ha respectively, with a small opening left of the setts which were closed up after sprouting. The application of postemergence (POE) 3—maize force at 179.2 g ha [metolachlor 375 g L^{-1} plus terbuthylazine 125 g L plus mesotrione 37.5 g L^{-1}] was applied at 5 weeks after planting (WAP). The NPK fertilizer was applied at 150 kg N, 60 kg P_2O_5 and 90 kg K_2O in equal halves at planting and 10 WAP. Irrigation water was applied at 41.3 L per plot once per week from February to April. Rainfall was supplemented with irrigation in May which was the establishment of the rainy season.

The treatments consisted of a factorial combination of two sugarcane genotypes [Chewing cane (Bida local and Industrial cane (NCS 001)], four rates of sugarcane trash mulch rates (0, 3, 6, 9 t ha^{-1}) and four weed management practices [weedy check, five monthly hoe weeding (5 MHW), pre-emergence (PE) application of diuron at 2 kg a.i ha^{-1} + post-emergence (POE) application of 3 – maize force at 179.2 g ha^{-1} + 2 MHW, and PE diuron + POE 3-maize force] making a total of 32 treatments arranged as a split- plot in a Randomized Complete Block Design and replicated three times. Weed management practices and trash mulching were allocated to the main plot, while sugarcane genotypes were the subplot. The gross plot size was 5 m x 4 m (20 m^2), while the net plot size was 5 m x 2 m (10 m^2). Each net plot consisted of four rows of 5 m length.

RESULTS AND DISCUSSIONS

In 2016 plant crop, with the exception of all the weed parameters and evapotranspiration that negatively correlated with cane yield, all the growth and yield characters as well as nitrogen content measured, correlated significantly and positively with cane yield (Table 1). The strongest relationship between the growth parameters and the yield in 2016 plant crop was found between millable stalk and cane yield (r=0.716**), followed by the relationship between stalk height and yield (0.677**). In 2017 plant crop, all the growth and yield characters as well as phosphorus and potassium content measured, correlated positively but not significant with cane yield with the exception of all the weed parameters and evapotranspiration that negatively correlated with cane yield. Organic matter, nitrogen and moisture content correlated positively and significantly with cane yield. The strongest relationship between the growth parameters and the yield in 2017 plant crop was recorded between organic matter and cane yield (r=0.537**), which was in turn the strongest relationship between any two growth parameter in this year (Table 1).

Similarly, in the ratoon crop of 2017, sprouting (%), tiller per plot, stalk height, brix, millable stalks and nitrogen content positively and highly significantly correlated with cane yield, while weed parameters and evapotranspiration were negatively correlated with cane yield (Table 1). The strongest relationship between the growth parameters and the yield in 2017 ratoon crop was recorded between brix and cane yield (r=0.590**), followed by the relationship between stalk height and yield (0.585**). Also, in 2018 ratoon crop, stalk girth, brix, organic matter, nitrogen and moisture content positively and significantly correlated with cane yield while weed parameters and evapotranspiration were negatively correlated with cane yield (Table 1).

Table 1. Correlation coefficient between sugarcane yield (t ha^{-1}) and some weed, growth and soil properties for sugarcane genotypes in 2016 to 2017 wet and dry seasons at Badeggi

	Dependent variable (Cane yield t ha^{-1})

Independent variables	Plant Crop 2016	Plant Crop 2017	Ratoon Crop 2017	Ratoon Crop 2018
Weed biomass at 3 MAP	-0.395*(0.02)	-0.373*(0.02)	-0.492*(0.03)	-0.473*(0.03)
Weed biomass at 6 MAP	-0.384*(0.02)	-0.373*(0.03)	-0.501**(0.01)	-0.556**(0.01)
Weed biomass at 9 MAP	-0.361*(0.03)	-0.427*(0.07)	-0.468*(0.05)	-0.537**(0.01)
Sprouting % at 3WAP	0.531**(0.001)	0.021ns(0.06)	0.531**(0.01)	0.202*(0.03)
Tiller per plot at 2 MAP	0.574**(0.01)	0.274*(0.03)	0.574**(0.01)	0.275*(0.04)
Stalk height at 12 MAP	0.677**(0.01)	0.290*(0.04)	0.585**(0.01)	0.261*(0.04)
Stalk girth at 10 MAP	0.595**(0.01)	0.280*(0.18)	0.202ns(0.18)	0.595**(0.01)
Brix at 12 MAP	0.595**(0.01)	0.446*(0.05)	0.590**(0.01)	0.539**(0.01)
Millable stalks at 12 MAP	0.716**(0.01)	0.296*(0.04)	0.576**(0.01)	0.317ns(0.06)
Organic matter	0.103ns(0.07)	0.537**(0.01)	0.068ns(0.07)	0.568**(0.01)
Nitrogen	0.532**(0.01)	0.523**(0.01)	0.543**(0.01)	0.523**(0.01)
Phosphorus	0.395**(0.01)	0.445**(0.01)	0.334**(0.01)	0.395**(0.01)
Potassium	0.371**(0.01)	0.272**(0.01)	0.316**(0.01)	0.397*(0.04)
Evapotranspiration (ET)	-0.402**(0.01)	-0.500ns(0.1)	-0.441*(0.02)	-0.475**(0.01)
Moisture content	0.264*(0.02)	0.526*(0.05)	0.380**(0.01)	0.531**(0.01)

*Significant at 0.05, ** highly significant at 0.01, ns-not significant, P-value in parenthesis

The strongest relationship between the growth parameters and the yield in 2018 ratoon crop was recorded between stalk girth and cane yield (r=0.595**), which was in turn the strongest relationship between any two growth parameter in this year

The significant and positive correlations observed between some growth and yield parameters particularly sprouting %, number of tillers, stalk height, stalk girth, brix, millable stalks with yield suggest that these characters are important cane yield contributing determinants. This finding agreed with that of Takim *et al*. (2014) who reported significant and positive correlation between number of tillers and cane yield. Flavio *et al*. (2013) reported similar results between number of tillers, stalk girth, brix, millable cane and cane yield. It implies that sugarcane breeders need to consider these characters in breeding for yield. Similarly, N and P were significant and positively correlated with cane yield. These indicate that these soil nutrients are essential yield contributing factors. This finding agreed with the work of Vitti *et al*. (2010) and Fortes *et al*. (2012) who reported significant and positive correlation between organic matter, N and P with cane yield. The importance of soil amendment in sugarcane cannot be overemphasized. Soil moisture content (SMC) was significant and positively correlated with cane yield. This is because the more the availability of water for plant use, the better the nutrient translocation which in turn affected growth and yield of sugarcane. This finding agreed with the work of Ball-Coelho *et al*. (2009); Peres *et* *al*. (2010) and Cheong and Teeluck (2015) who reported similar results between soil moisture content and cane yield.

CONCLUSION:

The selection programme for high yielding sugarcane would be effective if it was based on sprouting percentage, number of tillers, number of millable canes, sugarcane stalk girth and height, sugarcane brix, organic carbon, nitrogen and soil moisture content.

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The efefct of different watering regime on dry season cucumber production in nekede owerri west, imo state.

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ABSTRACT

A field experiment was carried out at the Department of Agricultural Technology, School Farm Federal Polytechnic Nekede to determine the effect of different watering regimes on dry season of cucumber (cucumis sativus L) using irrigation methods, The experiment was laid out in a Randomized complete Block Design (RCBD) using 3 different replicates. The treatments were four different watering regimes, the parameter collected include plant height, Numbers of leaves, fruit length, fruit girth, fruit weight, number of days of flowering, number of days of emergence, reading were taken at 2, 4and 6 weeks after planting. All the data collected were subjected to analysis of variance. From the result obtained, it was observed that some of the parameters were not significantly different while some were significantly different. DAYS TO 50% emergence of cucumber was significantly increased by the treatment 3 which is (watering using manual watering can aided with grass mulching material) however, plant that received furrow irrigation alone T2 took shorter time to emerge when compared with other treatments. Significantly taller cucumber plants were observed in treatment 1 and treatment 4 this could be attributed to evenly distributed water application following the method used as well as the mulching material used in treatment 4 (use of ultraviolent ray tarpaulin with the drip irrigation). The number of leaves also follow similar trend as plant higher above. The yield of cucumber were not significantly affected by different watering regime. However, yield was more enhanced in treatment 4(use of ultraviolent ray tarpaulin with the drip irrigation).
Keywords: Cucumber, Dry Season, Water Regime

INTRODUCTION

Background Of The Study

Cucumber (*Cucumis sativus*) is one of the most popular and widely grown vegetable crops in the world and it belongs to the family cucurbilaceae. It is a typical vegetable that grows in warm. temperate and cool tropical regions. It is a vegetable that have little tolerance for water stress. (*Huai-Fu Fan et al*., 2014). Due to it increased demand, it is considered as one of the most important economic vegetables. From the various researches carried out on the crop, it was established that it requires more water than grain crops (*Li and Wang. 2000: Mao, 2003*).

It was discovered that fresh fruit yields of cucumber were highly affected by total volume of irrigation water at all growth stages (*Mao, 2003*).

The production of cucumber during dry season is encouraged for availability of fresh vegetables, despite the fact that traditional farmers rely on their experience to irrigate cucumber such as furrow and basin irrigation, it does not in most cases actually result into expected high yield with it attendant drudgery. The production of cucumber can be enhanced with adequate knowledge of crop water use and the application of the irrigation technique such as sprinkler is inevitable for vegetable production in the near future because of the salinity problem caused by traditional irrigation methods.

Researchers have found out that excess in watering and improper irrigation techniques leads to non-uniform distribution of water in crop field with reduced yield (*Motilvaet et al., 2000*).

Being aware of the water sensitivity of plant species and their responses to water, there is need to choose the most suitable irrigation method and scheduling for them based on the source and availability of water (Meiri,1992)(Gao,1994) reported that cucumber plants posses moderate deep root and shallow fibrous root system which make them efficient user of available moisture within the top 60cm of soil layer. Timely and adequate application of irrigation water is necessary for good yield. Hence, it is important to determine the growth period when the plants are susceptible to water usage to avoid water stress and optimize the yield from irrigated area (Pandey *et al., 2000*).

Previous studies have shown that fairly good knowledge of crop water use have resulted into proper irrigation scheduling to save water and increase yield (Zhang *et al*, 201I: Oweis *et al*., 2000).

Statement Of Problem

The seasonal cucumber production ranges from 1 50-290 ton/ha with a mean daily production of approximately l,500kg/ha/day excluding those from 2018 because of it short growth period and the influence of root rots disease, there is need to find a sustainable system of production all year round due to the health benefit of the vegetable.**1**

Objectives

The major objective of the study is to evaluate the effect of different watering regime/irrigation on dry season cucumber.

i) To compare the growth cucumber under the various water regime.

ii) To determine the yield of cucumber affected by the different water regime used

iii) To determine the best affordable water regime for dry season production of cucumber

The significance of this study is to determine the impact of variation on water availability on plant growth and crop yield using various irrigation systems. This is aimed to determine the quantity of water needed and how it affect crop yield during the dry season period.

MATERIAL AND METHODS

Treatment 1= water regime using drip irrigation.
Treatment 2 = use of furrow irrigation system.
Treatment 3 watering using manual watering can aided with grass mulching material.
Treatment 4 = use of Tarpaulin with the drip system.
The treatments were replicated in three blocks to reduce error. The experiment produced 12 treatments in combination.

The experiment was laid out in a Randomized Complete Block Design (RCBD) and treatments was randomly administered. A plot size measuring (15m x 9m) was cleared and bed made at 3m x 2m each with lm spacing in-between blocks, The seeds were planted at 3 seeds per hole and later thinned down to one seed per hole after 3 weeks, in the month of December. **T**he recommended NPK fertilizer application of NPK 15 15 15 at 150kg/ha was used. The improved seed variety was sourced from Thia-agro farm and was used for the experiment. Weeding was carried out periodically using the convention weeding method of hoeing and hand weeding.

Data Collection

Data was taken at 2 weeks interval on the following parameters

Days to 50% Emergence of Cucumber Seed: The number of days to 50 days emergence was counted as the number of days it took 50% of all planted seed to germinate above soil level. This was calculated by counting calender days.

Flowering: This is the number of days of flowering, this was recorded as the number of days it took 50% of the plant to produce visible flowers.

Plant Height (cm): The plant height was measured in 2 weeks, 4weeks, and 6weeks after planting with a meter rule. The meter rule was placed at the base of the plant and measured to the tip of the plant

Number of Leaves: The number of leaves were counted and recorded in 2weeks, 4weeks and 6weeks from each plot. This was calculated by counting the number of fully developed leaves on each tagged plant and recorded per plot

Fruit Length (cm): The length of the fruit was measured with a meter rule after harvesting from each plot. This was measured using a meter rule from the base of the fruit to the tip

Fruit Girth (circumference) cm: The Girth of the fruit was measured with thread and meter rule from each treatment.

Fruit weight (g): The cucumber were measured using electronic weighing balance.

Statistical Analysis: Data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by fishers least significant difference (F-LSD) at 5% level of probability using R desktop version 1.4.1717 (R core Team, 2021).

RESULTS AND DISCUSSION

Table 1 Effect Of Different Watering Regimes On The Number Of Days To 50% Emergence

Treatment	Days To 50% Emergence

T1 water regime using drip irrigation	6.00
T2 use of furrow irrigation system	5.08
T3 watering using manual watering can aided with grass mulching material	6.16
T4 use of ultraviolet ray tarpaulin with the drip system	4.0
LSD (0.05)	0.98

The table above showed that the number of days to 50% emergence of cucumber was significantly affected by the different watering regime. Treatment 4, significantly emerged at about four days after planting, while the other treatments emerged at about the same time of 5-6 days after planting.

Table 2 Effect Of Diferent Watering Regime On The Numbering Of Days To 50 % Flowering In Dry Season Cucumber Production

Treatment	Number Of Days Of Flowering
T1 water regime using drip irrigation	29.33
T2 use of furrow irrigation system	33.00
T3 watering using manual watering can aided with grass mulching material	35.00
T4 use of ultraviolet ray tarpaulin with the drip system	34.33
LSD (0.05)	2.35

The number of days to 50 % flowering of cucumber plants were significantly affected by the different watering regime. T1 (29.33) flowered significantly earlier when compared with the other treatments. These was followed by T2 which flowered at (33.00), T4 (34.33) and (35.00) respectively.

Effect Of Different Watering Regime On Cucumber Plant Height

At 2WAP, the plant height of the cucumber was significantly affected by the different watering regime. T1 use of trip tape irrigation gave significantly taller plants (17.16) when compared with T2 (7.08) with the shortest recorded plant height. Plant height recorded for T3 (13.83) and T4 (14.00) were not significantly different.

At 4WAP, similar result was also obtained, the use of trip tape irrigation gave significantly taller plant when compared with the other treatments. The use of furrow irrigation alone affected plant height at all the sampling time, as the treatment produced significantly shorter plant.

At 6WAP Plant height was not significantly affected by the different treatments

Table 3 Effect of Different Watering Regime on Cucumber Plant Height (Cm)

Treatment	Weeks after Planting (WAP)		
	2	4	6
T1 water regime using drip irrigation	17.16	50.66	114.08
T2 use of furrow irrigation system	7.08	37.58	110.08
T3 watering using manual watering can` aided with grass mulching material	13.83	48.33	113.75
T4 use of ultraviolet ray tarpaulin with	14.00	38.41	101.08

the drip system			
LSD (0.05)	5.41	3.45	NS

Effect Of Different Watering Regime On Number Of Leaves

At 2WAP, The number of leaves per Plant of cucumber was not significantly affected by the different watering regimes, Though T1 (19.25) produce plants with the highest number of leaves followed by T3 (13.16) and T4 (10.41) and T2 (12.41) respectively.

Table 4. Effect Of Different Watering Regime On Number Of Leaves

TREATMENT	Weeks after Planting (WAP)		
	2	4	6
T1 water regime using drip irrigation	19.25	25.33	78.50
T2 use of furrow irrigation system	12.41	22.50	50.58
T3 watering using manual watering can aided with grass mulching material	13.16	19.33	68.91
T4 use of tarpaulin with the drip system	10.41	17.50	46.25
LSD (0.05)	NS	NS	NS

At 4WAP, The table reveal that the number of leaves per plant of cucumber were not significantly affected by the different watering regime, T1 (22.50) again produces plant with the highest number of leaves when compared with the other treatments T3 (19.33), T4 (17.50) and T2 (15.33) respectively.

At 6WAP, The table show that the number of leaves per plant of cucumber were not significantly affected by the different watering regimes, though T1 (78.50) produces plant with highest number of leaves followed by T3 (68.91) and T2 (50.58) and T4 (46.25).

Table 5 Effect Of Different Watering Regime On Fruit Length (Fl) Of Cucumber

Treatment	Fruit Length (Cm)
T1 water regime using drip irrigation	14.18
T2 use of furrow irrigation system	13.50
T3 watering using manual watering can aided with grass mulching material	12.58
T4 use of ultraviolet ray tarpaulin with the drip system	15.08
LSD (0.05)	\NS

The Table shows that the Fruit Length of cucumber were not significantly affected by the different watering regimes. It was observed however that T4 Use of tarpaulin with the drip system recorded the highest fruit length value (15.08) when compared with the other treatments T1 (14.18) T2 (13.50) and T3 (12.58) respectively. The least value frecorded in cucumber fruit length was observed in the plots treated with watering can alone.

Table 6 Effect Of Different Watering Regime On Fruit Girth (g).

Treatment		Fruit Girth (Cm)
T1	water regime using drip irrigation	40.56
T2	use of furrow irrigation system	39.80
T3	watering using manual watering can aided with grass mulching material	37.56
T4	use of ultraviolet ray tarpaulin with the drip system	40.56
LSD (0.05)		NS

The table reveal that the Fruit Girth of cucumber were not significantly affected by the different watering regimes. The highest girdth values were recorded in T1 (40.56) and T4 (40.56) have same Girth, T2 (39.80) and T3 (37.56) had the least recorded girth value

Table 7 Effect Of Different Watering Regime On Fruit Weight of Cucumber

Treatment		Fruit Weight (Kg)
T1	water regime using drip irrigation	383.33
T2	use of furrow irrigation system	333.33
T3	watering using manual watering can aided with grass mulching material	353.30
T4	use of ultraviolet ray tarpaulin with the drip system	483.33
LSD (0.05		NS

The fruit weight of cucumber were not significantly affected by the different watering regime. T4 (483.33) had the highest recorded fruit weight when compared with the other treatments. The fruit weight includes T3 (353.30), T1 (383.00) and T2 (333.33) respectively. The result revealed that although different treatments were applied in dry season production of cucumber, none of these treatments significantly affected the growth and yield of cucumber, Although one could categorically say that the plants in treatment 3 watering using manual watering can aided with grass mulching material produced better fruit yield when compared with other treatments.

CONCLUSION

Water application to the field during dry season farming is very essential especially in vegetable production. The different watering regime for irrigating cucumber during dry season has proved to be worthwhile from this study. However, optimal use of water to meet crop requirement at any stage of growth has also resulted into appreciable level of yield as demonstrated in different yield obtained from different watering regime applied to the crop. Therefore, cucumber grown in irrigated condition showed good production responses. From the result of the experiment carried out so far, it can be inferred that yield is considerably appreciable when cucumber receives adequate water or moisture below which there are noticeable decrease in yield. Even though, the experiment has not established the optimum water use for irrigating cucumber that will give the optimum yield during dry season farming, the result has shown that the different watering regime has an effect on cucumber yield. This simply showed that moderate irrigation is essential. The analysis of water applied in each of crop's growth stages made it possible to classify their effects on the development of the yield. The Production of cucumber during dry season with planned watering regime is profitable. Having carried out this experiment on the effect of different watering regime on dry season Cucumber Production, the following are recommended Irrigation, irrespective of the method used, is recommended for optimum production of cucumber during dry season. More work should be done in different regions to confirm the best water regime for cucumber plant.

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Incidence and Severity of brown leaf spot caused by *Curvularia geniculata* on Fonio (*Digitaria* spp) in Nigeria

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ABSTRACT

A survey of brown leaf spot on Fonio (*Digitaria iburua and D. exilis*) was carried out in major Fonio growing areas of Nigeria in 2014 and 2015. The surveyed areas were Bauchi, Kaduna, Plateau and Nassarawa States. Two visits were made to each state in each of the years. In each LGA, three towns were selected and three farms were sampled in each town with a farm representing a replicate. With the help of a quadrat five sampling plots were assessed for disease incidence and severity in all the farms visited. In 2014, there were significant ($P \leq 0.05$) differences in incidence of brown leaf spot in all areas visited, however the highest incidence of brown leaf spot was recorded in Zawang (Plateau) which was not significantly different from all other locations except, Nahuta and Bogoro (Bauchi) which had the least incidence. In 2015, the incidence of brown leaf spot was also highest in Zawang and Kwaturu (Kaduna). Angware, Bogoro, Demank, Mbar, Nahuta, Munguna, Nyeleng and Gyara had the least incidence. There were no significant ($P \leq 0.05$) differences in brown leaf spot severity in all the locations in both years. The disease was more prevalent in Plateau and Kaduna States.

INTRODUCTION

Fonio (Acha) or hungry rice (*Digitaria exilis* and *Digitaria iburua* Family Poaceae) originated in West Africa and as a grain crop cultivated for centuries across fifteen countries in the Northwest Africa from Cape Verde Island to Chad, Ivory Coast and Cameroon (Jideani, 1999). Fonio is the most ecologically adapted and economically useful. species of the monocotyledons (Anon. 1996, Cruz, 2004) due to its ability to grow under marginal rainfall and low inputs However, it is underutilized and neglected also considered one of the lost crops in Africa (Anon. 1996). It has the potential to improve nutrition, boost food security, foster rural development and support sustainable use of the land. It is grown mostly in the central and northern states of Nigeria such as Bauchi, Kaduna, Kebbi, Nassarawa and Plateau states where it is locally called 'Acha' (Aliero and

Morakinyo, 2001). The three largest producers are Guinea, Nigeria and Cote d' Ivoire with production of 500 986, 82 750 and 19 263 tons from 466 622, 190 315 and 33 983 ha respectively (FAO, 2016). Both *Digitaria* species have shown to be susceptible to insect pests and diseases (Vietmeyer *et al.*, 1996; Kwon-Ndung and Misari, 1999) thus a contributing factor to low yield. However, despite its economic importance, very little is known about the diseases of fonio in Nigeria (Auta, 1983). The first case was reported in Samaru, Zaria, where the incidence of leaf blast caused by *Pyricularia* sp and *Helminthosporium* leaf spot were identified on fonio plants (Auta, 1983). Therefore, the objective of this study is to determine the occurrence and distribution of brown leaf spot on Fonio in major growing areas in Nigeria.

MATERIALS AND METHODS

A survey of brown leaf spot of Fonio (*Digitaria iburua and exilis*) was carried out in Fonio growing areas of Nigeria between the second week of July and last week of August, 2014 and 2015. The Fonio growing states surveyed were Bauchi, Kaduna, Plateau and Nassarawa states. Two visits were made to each state for each of the year. The reason for the visits at such periods was it is expected that fonio plants have attained these ages since individual locations have different planting date. Two Local Government Areas (LGA) were surveyed in Bauchi (Bogoro and Tafawa Balewa), three LGAs in Kaduna (Jabba, Kachia Kagarko), ten LGAs in Plateau (Barkin ladi, Bassa, Bokkos, Jos East, Jos South, Kanke, Mangu, Pankshin, Quanpan and Riyom) and one LGA in Nassarwa State (Wamba) were surveyed. For each LGA, three selected towns and three farms were sampled with a farm taken as a replicate. Using a quadrat of 30x 30 cm five sampling plots in farms that were up to a hectare and three for farms less than a hectare were assessed for infection visually

Disease incidence was estimated by counting the number of infected plants in each sampling plot and expressing this as a percentage of the total Fonio plants per plot (Tarr, 1981). This was carried out with the help of a quadrant of 30 cm x 30 cm.

$$DI=\frac{Number\ od\ individual\ diseased\ plants}{Total\ number\ of\ plants}\ X\ 100$$

For disease severity assessment individual plants within the sampling plot were scored in numerical disease rating scale of 1 – 5 where; 1=No spots on leaves, 2= 1-25 % of leaves with spots, 3= 26-50 % of leaves with spots, 4= 51-75 % of leaves with spots and 5= 76% and above leaves with spots (Tarr, 1981).The disease severity was calculated using the formula below as expressed in percentage:

$$DS=\sum\frac{Nx}{N(5)}$$

where; $\sum$ = Sum total, x = disease rating grade, n = number of plants per given grade, N= total number of plants examined per plot and 5= the maximum disease grade. Data collected were subjected to statistical analysis of variance (ANOVA) using SAS (2013) and means compared using the Student Newman Keuls (SNK) test at 5 % level of significance.

RESULTS

Acha growing locations in major producing states and the level of brown leaf spot infection is presented in Figure 1. Geographically the study area stretches between latitude $9^{0}0^{1}0^{11}$ N - $11^{0}0^{1}0^{11}$ N of the equator and between Longitude $8^{0}0^{1}0^{11}$E – 10^{0} 0^{1} 0^{11} E of the Greenwich Meridian covering Bauchi, Kaduna, Nassarawa and Plateau States (Fig 1). Areas with 20- 30 % severity were grouped as low severity, 30.1-40 % moderate severity while above 40 % high severity (Figure 1.)

The result of the various locations visited is presented in Table 1. In 2014, the highest incidence of brown leaf spot was recorded in Zawang which was not significantly ($P \leq 0.05$) different from all other locations except Nahuta and Bogoro which had the least incidence. In 2015, the incidence of brown leaf spot disease was also highest in Zawang and Kwaturu, however, this significantly ($P \leq 0.05$) varied with only Angware, Bogoro, Demank, Mbar, Nahuta, Munguna, Nyeleng and Gyara which had the least incidence that was not significantly different from other locations. There were no significant ($P \leq 0.05$) differences in brown leaf spot severity in all the locations visited.

The results according to states shows in 2014, the incidence of brown leaf spot was highest in Plateau state but it was not significantly ($P \leq 0.05$) different from locations in Kaduna state. Meanwhile the least incidence was recorded in Bauchi state and they were at par with Nassarawa and Plateau states. However, in 2015 Kaduna state had the highest incidence and it did not vary from locations in Plateau state while Bauchi had the least incidence Figure 2. For severity of brown leaf spot, Nassarawa state recorded the highest severity and it did not differ from other locations in Plateau state while the least severity was observed in Kaduna state during 2014 cropping season. In 2015, Kaduna state recorded the highest severity Figure 3.

DISCUSSION

The disease was more prevalent in all the locations in Kaduna and Plateau states than Bogoro and Nahuta in Bauchi State. The reason could be due to differences in agro ecological zones and variation in weather parameters which in some case might not have been favourable for the pathogen. Weather factors play a major role in the initiation of disease and each pathogen has its own optimum requirement for infection (Hardwick 2002). The presence of high temperature and frequent rainfall has been attributed to the incidence of Curvularia blight of Zoysia grass caused by *Curvularia inaequalis* in China (Kim *et al.*, 2000). The average rainfall in Kaduna state is 284 mm (August) while temperature is 24.5 -29 ^{0} C and Plateau has 308.6 mm in August and temperature 24.5- 27 ^{0} C (Weather records from State Agricultural Development Project). This could be the reason why the disease is more prevalent in Plateau and Kaduna states than Bauchi (rainfall -252 mm and Temperature 29 ^{0} C). Bauchi has drier days than Plateau and Kaduna states. Bawa (1992) reported the influence of weather on the spread and development of midrib disease of millet. In the report, it was discovered that Jibia in far north had lower disease incidence than Sokoto and Katsina, and this was attributed to the effect of hot dry weather which slows the rate of disease development. The differences in disease spread observed on the fonio fields could also be attributed to differences in time of planting, while some fields were planted at the onset of rains others were planted later in the season therefore making infection period to vary in different locations during the survey.

CONCLUSIONS

From the above results Brown leaf spot is found in all the fonio growing areas visited with higher incidences and severity in Kaduna and Plateau states.

Table 1: Incidence and Severity of fonio Brown leaf spot in surveyed location

	Disease incidence (%)		Disease severity (%)		
States/Locations	2014	2015	2014	2015	Fonio type
Bauchi					
T/ Balewa	24.46ab	29.30abc	24.3	33.6	*exilis*
Sara	30.00ab	34.00abc	28.0	42.6	*exilis*
Boi	27.60ab	30.67abc	28.1	34.6	*exilis*
Nahuta	22.30b	21.13c	26.3	31.3	*exilis*
Gyara	29.60ab	24.40c	27.0	44.0	*exilis*
Bogoro	20.36b	23.70c	25.7	33.3	*exilis*
Kaduna					
Ungwan Waje	31.87ab	39.06abc	25.7	32.6	*iburua*
Sada bege	36.30ab	44.83abc	24.7	36.0	*exilis*
Kurmin Bauna	25.46ab	40.00abc	28.1	37.3	*iburua*
Kurmin Jatau	29.13ab	34.10abc	28.3	32.0	*exilis*
Kurmin Jibrin	30.08ab	32.10abc	27.7	43.6	*exilis*
Kwaturu	34.83ab	54.33a	28.1	40.0	*exilis*
Kenye	29.03ab	43.46abc	24.0	31.0	*exilis*
Dura	42.66ab	43.00abc	46.6	50.7	*iburua*
Fai	37.76ab	44.97abc	31.7	50.6	*exilis*
Nassarawa					
Arum	28.60ab	36.03abc	27.3	34.6	*exilis*
Chigbo	30.20ab	32.10abc	35.3	43.6	*exilis*
Wamba	33.06ab	35.50abc	30.1	30.2	*exilis*
Plateau					
Demak	28.03ab	27.00bc	27.1	37.0	*iburua*
Doi	28.50ab	33.07abc	24.0	38.3	*exilis*
Du	39.46ab	40.06abc	31.6	48.6	*exilis*
Federe	31.76ab	32.40abc	27.0	36.0	*exilis*
Fir	33.80ab	39.80abc	26.7	44.0	*exilis*
Fobur	38.36ab	52.100ab	27.7	45.7	*exilis*
Foron	31.54ab	38.63abc	30.3	39.3	*exilis*
Ganawuri	37.00ab	47.07abc	34.3	34.3	*iburua*
Garam	28.93ab	29.80abc	32.6	37.7	*iburua*
Gindiri	33.03ab	31.70abc	30.6	34.0	*iburua*
Gotaop	37.06ab	42.67abc	33.6	43.0	*iburua*
Angware	26.76ab	25.90bc	30.0	40.6	*iburua*
Balang shipen	28.96ab	37.30abc	31.3	35.3	*iburua*
Heipang	35.43ab	37.30abc	30.0	36.6	*exilis*
Jipal	33.40ab	38.33abc	32.0	41.0	*iburua*
Koronfang	42.23ab	41.23abc	32.0	45.8	*iburua*

Lardang	29.06ab	35.80abc	37.0	41.3	*exilis*
Lato'ok	28.66ab	32.90abc	31.7	45.0	*iburua*
Lemoro	41.57ab	40.47abc	31.1	40.6	*iburua*
Mangun	43.33ab	33.40abc	26.7	37.6	*exilis*
Mbar	29.10ab	27.73bc	31.3	37.6	*exilis*
Miango	38.66ab	43.87abc	28.1	34.3	*exilis*
Munguna	31.33ab	27.100bc	36.0	38.6	*exilis*
Nyeleng	25.83ab	22.01c	26.0	32.3	*iburua*
Rukuba	36.46ab	34.100abc	29.6	34.7	*exilis*
Shiwer	27.03ab	40.36abc	32.0	40.0	*iburua*
Sho	33.36ab	36.00abc	30.0	37.6	*exilis*
Ta – hoss	29.13ab	42.00abc	29.1	39.0	*exilis*
Tof	28.96ab	28.73ab	20.7	31.6	*iburua*
Zawang	48.06a	55.13a	36.6	41.3	*exilis*
SE ±	44.221	93.686	0. 02	0.06	
Interactions (Mnths)					
July	45.596b	38.01b	39.4b	40.1b	
August	60.69a	60.26a	50.8a	57.3a	
SE ±	15.11	22.25	11.3	7.2	

For each set, means followed by the same letter in each column are not statistically different (P ≤ 0.05) using the student Newman keuls (SNK) test

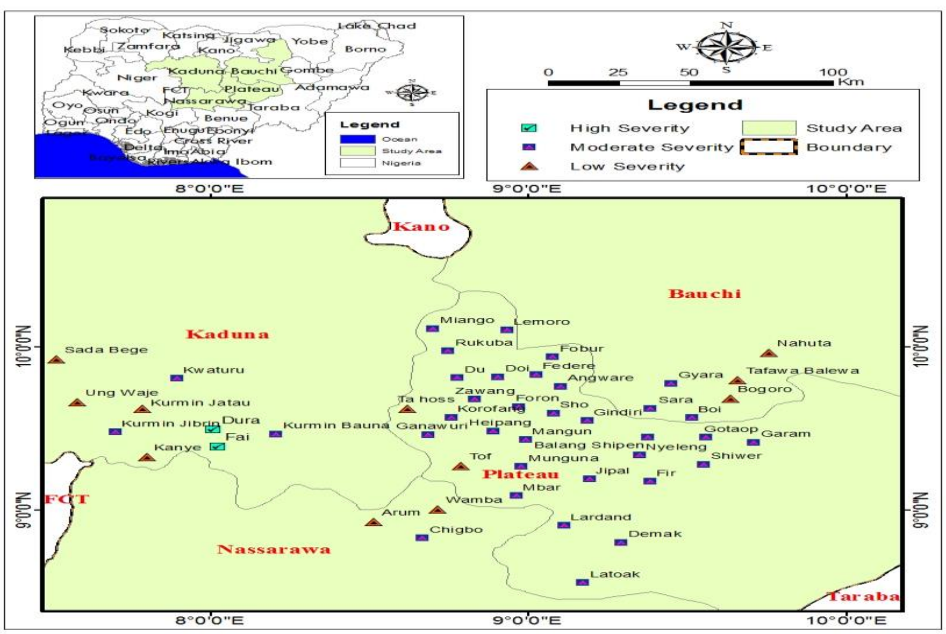


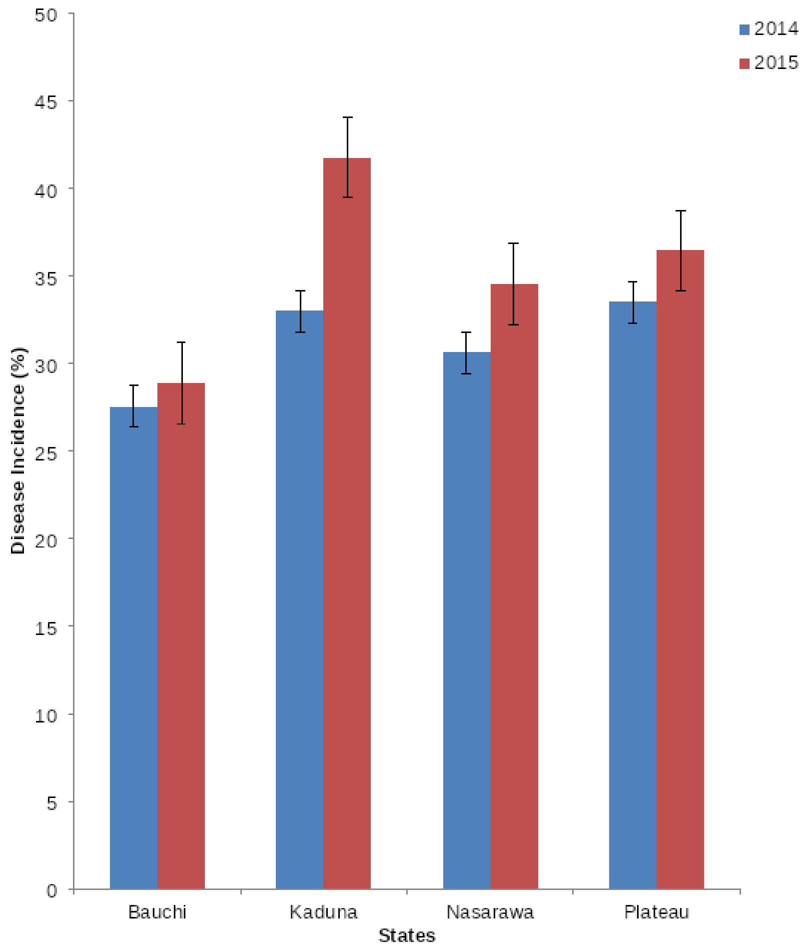
Figure 1: Distribution of Brown leaf spot in the surveyed areas

Key:

20- 30 % - low severity

30.1-40 % - moderate severity

> 40 % - high severity



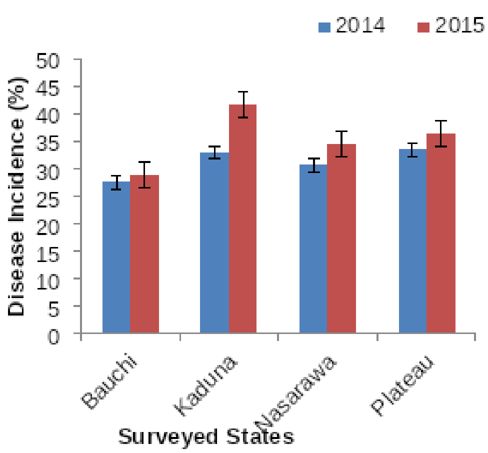


Figure 2: Incidence of brown leaf spot in surveyed states in Nigeria

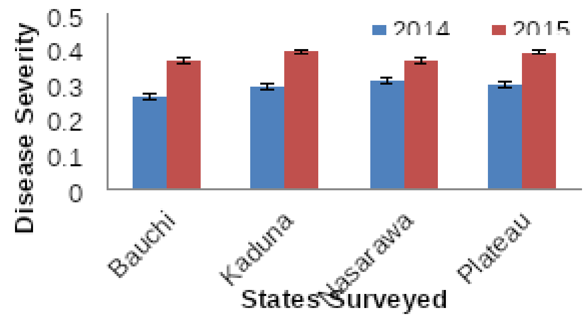


Figure 3: Severity of brown leaf spot in surveyed states in Nigeria

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Effect of variety on the chemical and functional properties of high quality cassava flour (HQCF) from cassava varieties (*Manihot esculenta* Crantz) tolerant to postharvest physiological deterioration (PPD)

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ABSTRACT
Four cassava varieties (NR87/184, TMS 07/0539, TME 419 and 01/1368) harvested (12 MAP) were carefully uprooted and stored at ambient temperature on shelves for a period ranging from 0 to 14 days. High quality cassava flour (HQCF) was processed from the stored roots at 0; 7 and 14 days after storage. The effects of variety on the chemical and functional properties of the flour were investigated. There were significant differences observed in the bulk density, water absorption capacity and swelling Index among the HQCF varieties and the days of processing. The hydrogen cyanide (HCN) content of the flour samples among the varieties decreased as the storage period progressed. There was significant difference among moisture, crude fibre and ash content values of HQCF samples within the storage days. The study shows that HQCF from different varieties of cassava roots tolerant to Postharvest Physiological Deterioration (PPD) can be stored up to 14 days and result in acceptable product in terms of moisture, crude fibre, ash and HCN contents.

Keywords: Cassava, HQCF, Postharvest Physiological deterioration and functional properties

INTRODUCTION
Cassava (*Manihot esculenta* Crantz) is cultivated in many regions of the developing world. It is important to the livelihoods of many millions of poor people who consume it as a staple in these regions (Alamu, Maziya-Dixon et al. 2017). Cassava thrives well in soils where many other crops perform poorly and thus plays an important role in food security (Iyer, Mattinson et al. 2010). Cassava roots are bulky and perishable and require appropriate strategies and technology for postharvest processing and utilization. Processing of fresh cassava roots provide a means of producing shelf-stable products (thereby reducing losses), adding value and reducing the bulk to be marketed (Ukpabi and Ndimele 1990). Cassava can be processed into different products such as chips, grits, flour, starch and syrup. High Quality Cassava Flour (HQCF) is one of the

intermediate products of cassava processing. It can be used as a substitute for wheat flour in the food industry as partial replacement for many baked and pasta products. Its special properties of clear appearance, low off-flavor and ideal viscosity makes it a vital ingredient in the food industry (Maziya-Dixon, Alamu et al. 2017). Postharvest Physiological Deterioration (PPD) is one major limitation of cassava roots utilization that causes a significant loss of storage roots, reducing the food, feed, and market value of the crop (Beyene, Solomon et al. 2018). Ideal operating conditions demand that the roots be processed on the day of harvesting or one or two days later. Studies have shown that some cassava varieties are tolerant to Postharvest Physiological deterioration (PPD) at ambient temperature for a period of 14 days. There is scanty information on the chemical and functional properties of high quality cassava flour (HQCF) from stored cassava roots (Manihot esculenta Crantz) tolerant to postharvest physiological deterioration (PPD). Availability of such information would guide in selection of cassava varieties that are suitable for marketing and utilization in enterprises requiring fresh cassava roots such as those that process snacks and other products.

MATERIALS AND METHODS

Four experimental cassava varieties was used for this study NR87/184 and TMS 07/0539 (white and yellow fleshed) tolerant to PPD and TME 419 white fleshed and 01/1368 yellow fleshed was used as check. Root samples were obtained from plants grown at the multiplication farm of Cassava Programme of the National Root Crops Research Institute Umudike, Umuahia, Abia State, Nigeria. The roots were harvested 12 months after planting and care was taken during harvesting to avoid injuries to the roots since root injury accelerates the onset of PPD. Cassava roots (ten kilograms each) of the four varieties NR87/184, TME 419, TMS 07/0539 and TMS 01/1368 without mechanical damage or pre-harvest rot were selected. Each of the ten kilograms harvested cassava roots were labelled day 0, day 7 and day 14. The sample of day 0 was immediately processed into HQCF while the remaining were stored at ambient temperature on shelves under a roof without walls for air to circulate freely and were equally processed into high quality cassava flour (HQCF) on days 7 and 14.

Preparation of high quality cassava flour (HQCF)

Ten (10) kg of cassava roots were manually peeled with stainless steel knife, the peeled roots were washed and re-weighed, grated, dewatered, and sieved. The resulting sieved mash was oven-dried at 40℃ and milled and sieved (sieve size, 0.5 mm).

Chemical and Functional Analyses of HQCF

The chemical (moisture, ash, crude fibre and ash contents) were determined using AOAC (2000) standard methods. The hydrogen cyanide content of flour samples were determined by the method described by Onwuka, (2005). Functional properties (water absorption capacity and bulk density) of the flour samples were determined by the methods described by Onwuka, (2005), while the swelling index of the flour samples was determined following the methods described by (Abbey and Ibeh 1988).

Statistical analysis

Data generated was analyzed statistically using R- Statistics, (R- programming language version 3.4.4). Statistical significance was established using analysis of variance (ANOVA) and means were separated using least significant difference (LSD) at $p \leq 0.05$.

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RESULTS AND DISCUSSIONS

The results of chemical properties high quality cassava flour (HQCF) from stored cassava varieties are shown in Table 1. The moisture, crude fibre, ash, and hydrogen cyanide contents ranged from 8.02 to 9.09%; 1.60 to 2.38 %, 1.31% to 1.42% and 1.60 to 3.72 % respectively. There was significant differences ($p<0.05$) in all the parameters and they all fell within the acceptable standard for HQCF. Moisture content is one of the factors that determine the shelf life of HQCF and low moisture observed for all the varieties confers higher shelf life on the flour. The concentrations of hydrogen cyanide in all the samples were within the maximum value (10 mg/kg) considered as National Standard Specifications for HQCF.

Typical functional properties examined in this study include; bulk density (BD), water absorption capacity (WAC) and swelling power or swelling index (SI). The results of the functional properties of high quality cassava flour cassava (HQCF) from stored cassava varieties are shown in table 2. Water absorption capacity of HQCF from the cassava varieties stored at different days significantly differed in this study and it ranged from 1.18 mL/g (TME 419) to 1.23 mL/g (NR 87/184) for day 0, 1.31 mL/g (TMS 07/ 0539 to 1.34 mL/g (NR 87/184) for day 7 and 1.20 mL/g (TMS 07/0539) to 1.27 mL/g (TME 419) for day 14. Water absorption capacity (WAC) is the ability of flour to absorb water and swell for improved consistency in food and it's desirable in food system to improve yield and, consistency and give body to the food (Offia-Olua ,2014). Flours processed at day 7 had highest WAC (1.31 mL/g- 1.34mL/g). High water biding ability of flours limits the amount of water available such that during mixing free water can migrate towards water biding sites and thus increase the viscosity of the products (Ajani, *et. al*., 2016).

CONCLUSION

At the end of this study, we made the following conclusions on HQCF processed from cassava varieties tolerant to Postharvest physiological deterioration (PPD); that all the flour samples contained residual hydrogen cyanide within the recommended National Standard Specifications for edible flours, and the flour samples had moisture contents within safe level limit. Flours processed at day 7 with higher WAC will be desirable in food system that needs improved yield and higher consistency. Finally, HQCF from different varieties of cassava roots tolerant to Postharvest Physiological Deterioration (PPD) can be stored up to 14 days and result in acceptable product in terms of moisture, crude fibre, ash and HCN contents.

Table 1: Effect of variety and processing days on the chemical properties of High Quality Cassava Flour (HQCF)

Variety	Processing Days	Moisture (%)	Crude fibre (%)	Ash (%)	HCN (mg/kg)
NR87/184	0	9.09	1.78	1.33	3.43
TME419	0	9.02	1.83	1.41	3.27
TMS01/1368	0	9.04	1.65	1.41	3.72
TMS07/0539	0	9.04	1.92	1.42	3.13
NR87/184	7	8.12	2.01	1.40	2.09
TME419	7	8.36	2.14	1.31	2.12
TMS01/1368	7	8.06	2.38	1.25	2.10
TMS07/0539	7	8.23	2.29	1.34	2.13

NR87/184	14	8.03	1.69	1.27	1.61
TME419	14	8.18	1.61	1.31	1.63
TMS01/1368	14	8.14	1.64	1.33	1.60
TMS07/0539	14	8.02	1.60	1.31	1.62
LSD		**0.06**	**0.05**	**0.03**	**0.22**

Table 2: Effect of variety and processing days on the Functional properties of High Quality Cassava Flour (HQCF)

Variety	Day of Processing (Day)	BD (g/mL)	WAC (mL/g)	SI
NR87/184	0	0.61	1.23	1.43
TME419	0	0.64	1.18	1.38
TMS01/1368	0	0.62	1.21	1.42
TMS07/0539	0	0.64	1.19	1.41
NR87/184	7	0.58	1.34	1.75
TME419	7	0.61	1.33	1.73
TMS01/1368	7	0.62	1.32	1.70
TMS07/0539	7	0.60	1.31	1.71
NR87/184	14	0.54	1.21	1.43
TME419	14	0.50	1.27	1.48
TMS01/1368	14	0.52	1.22	1.44
TMS07/0539	14	0.54	1.20	1.44
LSD		**0.02**	**0.02**	**0.02**

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Assessment of soil fertility of Idi - Iya farm site at ayetoro for sustainable cocoa cultivation – a case study of ayetoro village in yewa north local government area of ogun state nigeria.

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ABSTRACT

The study was conducted to evaluate the quality and suitability of the soil at Idi – Iya area of Yewa North Local Government Area in Ayetoro for possible cocoa production. The stratified random technique at depths of 0–15 cm, 15–30 cm, and 30-45 cm was employed for soil sampling. The samples were analyzed for pH, organic carbon (OC), nitrogen (N), available phosphorus (P), etc. The analytical results revealed that the mean value of soil pH falls within the allowable limits of between 4.5- 7.00 considered for cocoa production. The soil texture was generally sandy loam in nature. The soil organic contents (total nitrogen, available P, exchangeable cations (K+, Ca, Mg) were low compared to the critical value required for cocoa production in Nigeria. Hence, there would be a need for fertilizer applications for sustainable cocoa production to augment the deficiencies.

Keywords: Cocoa, Evaluation, Random techniques, Soil and Stratified

1.0: INTRODUCTION

The roles of soil in agricultural production and sustainability are quite enormous and cannot be overemphasized; hence, they must be properly catered for at the planning stages. Soil takes care of both micro and macronutrient elements, water, oxygen, and root support required by our crops to grow and produce bountiful yields. They also serve as a buffer to protect delicate plant roots from drastic fluctuations in temperature. However, soils that are primarily sand or heavy clay represent the extremes in soil types and may be more difficult to improve and grow certain crops at the desired or sustainable production level needed to support the farm.

In view of the very important and strategic roles played by soil in sustainable food security and production, site selection and its subsequent fertility evaluation prior to planting becomes imperative. Soil fertility evaluation of a selected site for agricultural purposes is the single most important factor in the fruit production process, which can make a very significant difference in how luxuriant and abundant the fruit will grow. This is because soil fertility examination has significant effects on the potential production of a given crop. The main objective of this study was therefore to assess the fertility status of soils at a farm site at Idi-Iya, located in the Ayetoro village area of Yewa North local government area of Ogun State, Nigeria for sustainable cocoa cultivation.

2.0: METHODOLOGY

The site was demarcated into two blocks based on the types of vegetation cover, topography and current land use. Soil samples were collected based on these identifiable features on the field. Soil samples were collected on the demarcated blocks in a stratified manner. Three soil samples were collected per augering point at 0 – 15; 15 – 30 and 30 – 45cm soil depths respectively with the use of soil auger. A total of 40 augering points were collected at three levels making a total of one hundred and twenty soil samples altogether across the site, these were later partitioned and composited to form sixty composite samples, the samples were well labeled, air dried and sieved to pass through a 2mm sieve. Samples were partitioned for different activities such as particle size analysis, pH determination, macro and micro nutrients determination etc. The particle size distributions of the soil across the augering points were determined in the laboratory using the hydrometer method as described by **(Gee and Bauder, 1996)**. The organic carbon (OC) content was determined using wet digestion method **(Carmo, and Silva. 2012)** while the pH of the soil in soil to water ratio of 1:2 was by the use of electrical pH meter. The soil total N content was determined by **Franzluebbers, et al., (2018)** while the available Phosphorus (P) was by the Bray 1 method **(Juo, 1996)**. Potassium is extracted from the soil by mixing 10 milliliters of 1 normal ammonium acetate, pH 7 with a 1 gram scoop of air-dried soil and shaken for 5 minutes. The available potassium is measured by analyzing the filtered extract on an atomic absorption spectrometer set on emission mode at 776 nm (**University of Minnesota, 2022)**.The exchangeable cations of Ca and Mg were extracted by leaching the soil with 1NNH4 OAC at pH 7 and the contents were determined by the use of flame photometer. Ca and Mg contents were determined by the use of atomic spectrophotometer (AAS). The soil micro nutrients (Fe, Mn and Cu) were also determined using AAS.

3. 0: RESULTS

3. 1: The Particle Size Analysis Results

The results of the mechanical analysis revealed that at the top soil (0–15 cm) depths, the sand contents ranged between 64.40% and 86.80% with an overall mean value of 79.58% sand; the clay particles ranged from 5.20 to 16.20% with an average value of 9.95% clay. The silt, however, ranged between 5.40 and 20.40% with a mean value of 10.93% silt content (Table 1). However, the mean average percentage of sand, silt, and clay contents at 15–30 cm depths, respectively, were 70.26; 15.73; and 11.76%, whereas at 30-45 cm depths, the values recorded were 73.85; 16.55; and 9.95%. The plot had a textural classification of sandy loam (**SL**) soil. The average Clay + Silt contents of 20.88% (0 - 15 cm) are less than the critical value of 32% (Egbe et al., 1989); however, this observation may not pose a threat to sustainable cocoa production in this area if good agricultural practices (e.g. sufficient mulching with dry grass or plastic mulch and planting of shade crops such as Plantain prior the establishment of cocoa seedlings) are implemented in conjunction with adequate daily water supply. This is necessary because the area lacks forest trees, which can cast necessary shade during the dry spell of the year.

3.3: The Soil Reaction (pH) Situation of the Site

The soil pH values within the 0–15 cm depths ranged from 5.83 to 6.52 with an average mean value of 6.13; at 15–30 cm depths, the pH ranged between 5.77 and 6.90 with a mean value of 6.00. However, at the deeper depths of between 30 and 45 cm, the soil acidity ranged between 5.89 and 6.50, with an average value of 6.11. Generally, the pH values across the field were found to be slightly acidic to slightly basic. This pH range falls within the pH that can be considered suitable for sustainable cocoa cultivation. However, efforts must be put in place to avoid practices that could further lower the pH of the plot. The degree of the acidity of the soil falls within the permissible limits of between 4.5 and 7.0, considered appropriate for better cocoa growth and establishment (Table 1).

Table 1: Soil physical characteristics and pH of samples collected at different locations

	0 – 15 cm					15 – 30 cm				30 – 45cm			
S/N	**pH (H_2O)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**TC**	**pH (H_2O)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**pH (H_2O)**	**Sand (%)**	**Silt (%)**	**Clay (%)**
1	6.10	86.40	5.40	8.20		5.84	77.40	13.40	8.20	6.42	78.40	13.40	8.20
2	6.21	80.40	8.40	11.20		6.24	68.40	17.40	14.20	6.26	76.40	13.20	10.20
3	5.98	78.40	11.40	10.20		6.05	72.00	17.40	10.20	5.98	67.40	17.40	13.20
4	6.39	85.40	9.40	5.20		5.83	73.40	18.40	8.20	5.66	74.40	19.40	16.20
5	6.30	79.40	9.40	11.20		5.77	62.40	21.00	11.20	6.05	62.40	23.40	14.20
6	6.30	80.40	9.40	10.20		5.90	70.20	12.40	9.20	6.02	76.40	14.40	9.20
7	5.96	79.40	10.40	10.20		6.01	68.90	13.40	14.20	5.98	73.90	16.40	9.20
8	6.10	80.40	9.40	10.20		5.98	70.10	17.40	10.20	6.10	73.40	18.40	8.20
9	6.20	82.40	9.40	7.20		6.01	66.50	19.40	8.20	6.20	70.40	20.40	9.20
10	6.52	84.40	8.60	9.00		6.03	64.40	23.40	16.20	5.89	75.40	12.40	12.20
11	5.90	86.50	7.60	6.90		5.85	71.40	14.40	8.20	6.06	65.40	23.40	11.20
12	6.10	82.60	8.60	8.80		5.87	65.80	16.40	10.20	6.12	78.40	12.20	9.40
13	6.40	80.40	9.20	10.40		6.02	62.90	18.40	15.20	6.24	78.00	12.00	10.00
14	6.00	86.80	10.40	8.80		6.44	70.20	20.40	16.20	6.20	74.40	16.40	9.00
15	6.05	79.20	9.60	11.20		5.80	76.40	12.40	14.20	6.50	70.40	19.40	10.20
16	6.16	76.40	14.40	9.20		6.02	72.80	11.20	16.00	6.43	79.40	12.40	8.20
17	5.88	69.40	16.40	14.20	**SL**	5.41	71.60	13.40	15.00	5.99	78.40	12.20	9.20

18	6.04	73.40	18.40	8.20	5.98	69.80	12.60	18.40	6.01	77.40	14.40	8.20
19	6.03	64.40	20.40	16.20	6.05	70.20	11.30	18.50	5.97	74.40	19.40	6.20
20	5.98	75.40	12.40	12.20	6.90	80.10	10.60	9.30	6.04	72.20	20.40	7.40
Mean	***6.13***	***79.58***	***10.93***	***9.95***	***6.00***	***70.26***	***15.73***	***11.76***	***6.11***	***73.85***	***16.55***	***9.95***

SL = *Sandy loam*

3.7: The exchangeable cations (K, Ca, Mg) contents of the sites:

(i): Calcium (Ca):
The soil Ca contents at 0–15 cm depth ranged from 1.68–3.42 cmol/kg soil, with a mean value of 2.38 cmol/kg soil. The values ranged from 0.01 to 0.05 cmol/kg soil, with a mean value of 0.06 cmol/kg soil Ca at 15 to 30 cm depth. At the depths of 30 to 45 cm, the Ca values ranged from 1.68 to 3.46 cmol/kg soil Ca, with an average of 2.35 cmol/kg soil (Table 2).

(ii): Magnesium (Mg):
At the top soil layer of 0–15 cm, magnesium contents in the soil ranged from 0.31–1.03 cmol/kg soil with the mean average magnesium contents in the soil being 0.67 cmol/kg soil, while at 15–30 cm depth, the magnesium contents ranged from 0.42–0.90 with a mean of 0.65 cmol/kg soil. The mean soil Mg contents at 30 to 45 cm depths were 0.57cmol/kg soil respectively. Generally, the mean values of 0.67; 0.65 and 0.57 cmol/kg soil respectively were far below the critical level of 0.8cmol/kg soil (Table 2).

(iii): Potassium (K):
The soil exchangeable K at 0 - 15cm soil depths varied from 0.02 – 0.09 cmol/kg soil K with a mean value of 0.04 cmol/kg soil K, The K at 15–30cm depths ranged between 0.01 – 0.05 cmol/kg soil K with a mean value of 0.04 cmol/kg soil whereas, at 30 – 45cm depths, the K values range between 0.02 – 0.09 with an average value of 0.03 cmol/kg soil (Table 2)

Table 2: Result of the Exchangeable Bases at different locations and depths

	Ca (cmol/kg)			**Mg (cmol/kg)**			**K(cmol/kg)**		
Locations	**0 - 15cm**	**15 - 30cm**	**30-45cm**	**0 - 15cm**	**15 - 30cm**	**30-45cm**	**0 – 15cm**	**15 - 30cm**	**30 – 45cm**
1	3.10	0.02	3.10	0.68	0.55	0.68	0.08	0.02	0.08
2	2.11	0.04	2.11	0.58	0.48	0.58	0.04	0.04	0.04
3	1.85	0.03	1.85	0.69	0.67	0.69	0.04	0.03	0.04
4	2.45	0.01	2.45	0.88	0.75	0.88	0.02	0.02	0.02
5	2.86	0.03	2.86	1.02	0.68	0.02	0.03	0.01	0.02
6	1.97	0.04	1.97	0.47	0.72	0.47	0.04	0.03	0.02

7	3.22	0.02	3.22	1.03	0.65	0.03	0.05	0.04	0.04
8	2.15	0.03	2.15	0.41	0.56	0.41	0.02	0.02	0.04
9	2.48	0.03	2.48	0.79	0.82	0.79	0.03	0.03	0.02
10	2.01	0.03	2.01	0.36	0.58	0.36	0.02	0.03	0.02
11	3.46	0.04	3.46	0.96	0.86	0.96	0.04	0.04	0.04
12	1.97	0.03	1.97	0.76	0.90	0.76	0.04	0.03	0.04
13	2.86	0.02	2.86	0.81	0.76	0.81	0.05	0.02	0.04
14	2.15	0.01	2.15	0.31	0.74	0.31	0.09	0.01	0.09
15	1.93	0.04	1.93	0.74	0.42	0.74	0.04	0.04	0.04
16	1.68	0.03	1.68	0.56	0.58	0.56	0.03	0.03	0.03
17	2.01	0.05	2.01	0.60	0.60	0.60	0.06	0.05	0.06
18	1.80	0.04	1.80	0.41	0.52	0.41	0.02	0.04	0.02
19	3.01	0.03	3.01	0.65	0.46	0.65	0.03	0.03	0.03
20	1.90	0.02	1.90	0.72	0.65	0.72	0.02	0.02	0.02
Mean	***2.38***	***0.03***	***2.35***	***0.67***	***0.65***	***0.57***	***0.04***	***0.04***	***0.03***

3.4: The Total Nitrogen (N)

The total N contents at the first 0–15 cm depths ranged from 0.03–0.09% with a mean value of 0.06% (Table 3). The N values at 15–30 cm and 30-45 cm depths varied with depth, with average values of 0.04 and 0.06%, respectively. The mean N values across the plots were very low and below the critical level of 0.09%, but with good agricultural practices such as intercropping with leguminous crops like Cajanus – Cajan, Egusi – melon and Cowpeas coupled with application of organic fertilizer for better soil fertility management, the plot can be used for cocoa establishment. Due to the shallow nature of the soil, efforts must be made to provide adequate shade, water, and committed labour that will work all year round on the farm.

3.5: The Soil Available Phosphorus (P):

The soil available P contents varied from 0.37 to 1.91 mg/kg-1 soil with a mean of 1.19 mg/kg-1 soil at the depths of 0–15 cm soil; the average P values at 15–30 and 30-45 cm depths were 0.03 and 0.04 mg/kg-1 soil, respectively (Table 3). The available P contents were generally far below the critical value of 10.00 mg kg1 soil needed for good cocoa performance; hence, there will be a need for phosphorus-based fertilizer during the second growing season of cultivation.

3.6: The Soil Organic Carbon (OC):

The soil organic carbon (OC) at 0–15 cm soil depths ranged from 0.39–1.27% with a mean value of 0.74%. Similarly, at 15 cm and 30-45 cm depths, the organic matter contents varied respectively; they ranged between 0.51 and 0.91% with an average value of 0.66% and from 0.44 to 1.03% with a mean value of 0.66, which were also found to be far below the critical value of 3.00%, an amount that is required for coca production in Nigeria (Table 3). The low OC nature of the soil could be a result of previous usage by the local farmers. Although the OC was low, it can be improved with organic-based fertilizer, a good cropping system, good agricultural practices, and well-planned and regulated soil nutrient management systems. However, the generally low level of OC content in soils is an indication that the soil N will need some amendments in terms of fertilizer (organic and inorganic) for sustainable cocoa production in the long run to support cocoa growth.

Table 3: ***Result of the essential Macro and some micro nutrients at different depths***

Location	Total N %	Org. C %	AV.P mg/kg	Total N	Org C %	Av P mg/kg	Total N %	Org C %	Av.P mg/kg
		0 – 15cm			0 – 15cm			0 – 15cm	
1	0.04	0.63	1.33	0.05	0.62	0.02	0.06	0.60	0.08
2	0.06	0.85	0.70	0.06	0.81	0.04	0.06	0.75	0.04
3	0.06	1.00	1.63	0.05	0.91	0.03	0.07	1.03	0.04
4	0.07	0.91	0.51	0.08	0.82	0.02	0.09	0.81	0.02
5	0.09	1.27	0.56	0.09	0.60	0.01	0.04	1.00	0.02
6	0.04	0.39	0.37	0.05	0.80	0.03	0.09	0.30	0.02
7	0.09	0.85	1.68	0.04	0.74	0.04	0.06	0.88	0.04
8	0.06	0.63	0.61	0.05	0.68	0.02	0.08	0.60	0.04
9	0.08	0.65	1.03	0.04	0.60	0.03	0.05	0.55	0.02
10	0.05	0.75	1.68	0.03	0.58	0.03	0.04	0.45	0.02

11	0.04	0.64	1.82	0.04	0.54	0.04	0.04	0.44	0.04
12	0.04	0.59	1.45	0.04	0.51	0.03	0.04	0.69	0.04
13	0.07	0.56	1.40	0.03	0.61	0.02	0.07	0.50	0.04
14	0.06	0.72	1.91	0.02	0.63	0.01	0.06	0.68	0.09
15	0.06	0.51	2.85	0.01	0.59	0.04	0.06	0.51	0.05
16	0.03	0.57	0.62	0.04	0.51	0.04	0.03	0.50	0.07
17	0.05	0.65	0.45	0.05	0.59	0.05	0.05	0.63	0.03
18	0.06	0.78	1.01	0.02	0.81	0.03	0.06	0.68	0.02
19	0.07	0.92	0.91	0.03	0.60	0.06	0.07	0.82	0.02
20	0.07	0.88	1.21	0.03	0.65	0.05	0.04	0.78	0.06
Mean	***0.06***	***0.74***	***1.19***	***0.04***	***0.66***	***0.03***	***0.06***	***0.66***	***0.04***

3.8: Micronutrient Contents:

The average micronutrients (Mn, Fe, and Zn) contents of the site varied between locations within the site. The mean values of Mn contents at 0–15; 15–30; and 30-45 cm depths were 9.99; 5.17; and 5.40 mg/kg, respectively (Table 4). For Fe, the mean values were 2.19, 1.84, and 2.42 mg/kg soil, while Zn recorded average values of 2.86 at 0-15 cm, 0.33 mg/kg at 15- to 30-cm depths, and 0.95 mg/kg at 30- to 45-cm depths, respectively. The micronutrients are needed in a small quantities by the proposed choice crop; hence, micronutrients may not pose any threat to the proposed crop.

Table 4: Soil micronutrients contents across the different points and depths

Locations	Micronutrients								
	0 – 15 cm			15 – 30cm			30 – 45cm		
	Mn (cmol /kg)	Fe (cmol /kg)	Zn (cmol /kg)	Mn (cmol /kg)	Fe (cmol /kg)	Zn (cmol /kg)	Mn (cmol /kg)	Fe (cmol/ kg)	Zn (cmol /kg)
1	14.00	0.60	0.40	2.50	0.31	0.40	3.90	0.95	0.20
2	11.15	0.15	0.65	6.10	0.10	0.50	13.60	2.90	0.45
3	5.60	4.65	0.55	0.75	4.20	0.40	3.65	2.40	0.62
4	14.14	2.30	0.50	15.95	4.25	0.15	0.90	4.50	0.28
5	4.70	0.40	0.50	2.55	0.70	0.25	4.05	5.45	0.16
6	11.10	1.45	0.20	4.40	1.44	0.20	6.38	0.68	0.44
7	8.60	2.61	0.45	6.12	0.21	0.30	3.06	1.95	0.26
8	9.80	4.01	050	6.50	3.65	0.40	6.19	3.21	0.80
9	10.17	3.65	0.20	4.63	4.12	0.20	6.35	2.00	2.14
10	12.16	0.32	0.30	10.66	3.44	0.18	8.31	4.21	3.50
11	13.45	0.86	0.15	6.14	2.85	0.14	9.33	1.86	3.12
12	10.91	4.21	0.25	7.62	0.30	0.42	11.35	2.44	0.32
13	7.45	5.10	0.35	3.66	0.26	0.20	2.43	3.20	1.80
14	7.20	0.80	0.40	2.90	2.00	0.55	7.10	0.85	0.60
15	8.91	2.12	0.16	3.62	1.01	0.45	1.32	2.14	0.65
16	13.00	1.20	0.18	0.89	0.20	0.35	2.85	3.01	1.05

17	6.90	0.80	0.30	5.72	2.16	0.65	3.54	2.02	0.65
18	10.46	3.75	0.75	2.94	0.88	0.35	4.10	0.45	0.75
19	11.64	2.95	0.65	7.35	4.30	0.25	5.33	2.05	0.29
20	8.50	1.92	0.35	2.45	0.41	0.25	4.21	2.11	0.88
Mean	**9.99**	**2.19**	**2.86**	**5.17**	**1.84**	**0.33**	**5.40**	**2.42**	**0.95**

4.0: Discussion

The site's textural classification was generally sandy loam soil (SL) throughout the soil profile. The mean clay and silt content of the site at 0–15 cm depths was far below the critical level required for cocoa cultivation. So, there should be sufficient water supply through irrigation during the first three years of establishment throughout the dry season periods of three to four months as the case maybe. Plantains could also be planted as shade crops although not sufficient during these periods because most of the plantain stands die off. This is because the soil may not be able to hold sufficient amounts of soil moisture (water) for a long time because of the sandy nature of the soil. Therefore, sufficient arrangements must be made during these periods of the year to supply water in adequate and sustainable quantities. The non-existence of a naturally flowing source of river water in the location suggest an alternative water supply hence, the need for a deep well (s) or borehole(s) is/are highly essential to supply water for irrigation purposes during the dry season of the year, especially during the first three years of field establishment (if it could be afforded by the farmer). The borehole can be piped and connected to a gasoline-powered pumping machine for effective water delivery during the periods for even distribution and delivery of irrigation water to the various sections and parts of the field. During the dry periods of the year, the presence of a few standing forest trees would provide natural shade for the young, growing cocoa seedlings on the farm land. The soil organic carbon (OC), although low, can be improved with good agricultural practices and a good cropping system. As a result, fertilizer application regimes (organic or inorganic) that take into account both macro and micronutrient needs of the plot within the first three years of growth of cocoa seedlings on the field would be required to enhance good establishment. The soil exchangeable cation of magnesium (Mg) was observed to be inadequate and lower than the critical level of 0.8 mg/kg soil in most of the points where soil samples were collected within the plots. The soil reaction and pH values were within the range ideal for cocoa crop performance.

4.1: RECOMMENDATIONS:

Based on the observations and results of the study, the proposed site will be suitable for the purpose for which it was intended if:

1. Provision of all-year-round water supply, especially during the dry season of the year, through the sinking of deep wells or boreholes at reasonable distances to cover the entire farm
2. Provision of trickle irrigation to optimize water usage and minimize waste. This could be improvised by using Eva water bottles with a needle perforated cap, filled with water, and placed very close to the base of cocoa seedlings. It should be noted that the distal end of

the water-filled bottle must be raised and supported with a stone or small piece of wood for ease of water delivery in trickle form to the base of cacao.

3. Adequate mulching can be provided during the dry season around the young cocoa seedlings to guard against high rates of water loss through evaporation of surface water.
4. Sufficient shade is provided to provide a needed microclimate for the survival of the proposed crops.
5. Adequate use of the right choice of recommended fertilizer that can supply a sufficient amount of the needed nutrients is provided.
6. Good access roads could be provided to link the farm to the nearby towns and villages for ease of transportation of the cocoa products to buyers within the state.
7. Planting materials, especially cocoa seeds, are sourced from (C.R.I.N.), Ibadan.
8. Other alternative crops like Oil palm trees, Cashew etc can be planted as companion crops.

4.2: CONCLUSION:

Based on the results obtained from the routine laboratory analysis of both physical and chemical properties of the soil collected from the proposed site at Idi-Iya, in Aiyetoro village, Yewa North Local Government Area of Ogun State, It is therefore concluded that the proposed site chosen for the establishment of cocoa seedlings will support the purpose for which it was meant if the above-itemized recommendations and suggestions are followed.

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Growth of rice (*oryza sativa* l.) Varieties as influenced by seedling ages in sudan savanna ecological zone of kebbi state, nigeria

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ABSTRACT

Field experiments were conducted in National Cereals Research Institute low land research field Gwadangaji area, Birnin Kebbi (lat. 12°12.99' N; long. 4° 21.90'E; 197m above sea level) during 2020 and 2021 rainy seasons which is located in the Sudan Savanna ecological zone of Nigeria. The aim was to study the response of rice varieties to age of seedling at transplanting. The treatments consisted of factorial combination of three rice varieties (Faro44, Faro52 and Faro57) and five (5) seedlings age; 10, 20, 30, 40 and 50 days, laid out in a randomized complete block design (RCBD), with three replications. The size of each plot was 3 m x 2 m (6 m^2). Results revealed that plant height, number of tillers, leaf area index, crop growth rate (CGR), relative growth rates were higher with Faro 57 and Faro 52 in conjunction with seedling age of 30 days old. Interaction showed that all the three varieties (Faro 44, Faro52 and Faro57) attained maximum growth with seedling age of 30 days. It could be concluded that Faro 57 and Faro 52 out yielded Faro 44. Also, seedling age of 30 days resulted in the higher growth attributes of rice.

Keywords: Rice, Variety, Seedling age, Growth

INTRODUCTION

Rice belongs to the grass family Poaceae and the genus Oryza. The *Oryza genus* contains about 20 different species of which only two are currently cultivated*; Oryza sativa* and the *Oryza glaberrima* with origin from Asia and Africa, respectively. The species varied in statute, life cycle and adaptation (Maji *et al*., 2014). Substantial amount of water is required for its production (Padhi, 2004). Rice is a staple food for over 50% of the global population making it the most important food crop (More *et al*., 2007). Rice yield in Nigeria is relatively low (1.81t/ha) despite abundant area put to rice production and availability of suitable ecologies, suitable climatic conditions and the availability of improved high yielding varieties farmers still record low yields. This low yield is attributed to poor agronomic practices, particularly the nursery and transplanting procedures. Considering the water requirement for rice production and the cost of pumping water during the dry season it is pertinent to relate age of seedling at transplanting with days to maturity, as delay in transplanting affects growth and yield (Muhammed *et al*. 2017). Late transplanting delays maturity compared to early transplanting which results to longer days of irrigation, thereby increasing the cost of production. Transplanting rice too late affects root establishment and tillering ability and grain formation which reduces productivity of rice (Sarker *et al*., 2012). Varieties vary in their days to maturity so it is very important to determine appropriate age of seedling at transplanting for each variety. For effective extension package on rice production in Sudan Savana region like Kebbi State, a scientific knowledge on the most appropriate age of seedling at transplanting for various varieties of rice is necessary. The main aim of this paper is to determine the growth performance of some selected rice varieties as influence by seedling ages in the study area.

MATERIALS AND METHODS

The experiment was conducted at the research field of the National Cereals Research Institute (NCRI) Sub-station, Gwadangaji in Kebbi State (Sudan savanna agro ecological zone), during the 2020 and 2021 rainy seasons. The average annual rainfall of the area ranges from 650 mm-750 mm per annum and the relative humidity ranges from 21-40% and 51-79% during the rainy and dry seasons, respectively. The temperature varied from 18 to 31^{o}C in the dry season and 27-41^{o}C in the wet season (NIMet 2021). The treatment consisted of three rice varieties (FARO 44, FARO 52 and FARO 57) and five seedling ages (10, 20 30 40 and 50 days old), making a total of fifteen treatment combinations, laid out in a Randomized Complete Block Design (RCBD) with three replications. All the three varieties were sourced from the breeding unit of NCRI, Badeggi, Niger State.

Nursery was established at the experimental field of NCRI sub-station. Raised beds of 2 x 5 m (10 m^2) were constructed and the seeds were broadcasted on the bed and lightly covered with thin layer of soil, the beds were regularly irrigated to keep them wet but not flooded. The seedlings were transplanted starting at 10, 20, 30, 40 and 50 days after sowing according to the treatments at spacing of 20 x 20 cm. Prior to transplanting, the nursery beds were irrigated to facilitate easy lifting of seedlings. After transplanting, the plots were flooded to a depth of 2cm which was increased to 3-5 cm up to physiological maturity stage. Data were collected on number of tillers, leaf area index, crop growth rate and relative growth rate. Data generated were analyzed using analysis of variance procedure, and treatment means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Number of Tillers

Results on number of tillers of rice varieties as affected by seedlings age for both years is presented in Table 1. Tillering influences grain yield of rice as it is closely linked to the final panicle number produced per unit area of cultivated land (Quyen *et al.*, 2004). In 2020, at 6 WAT, more tillers were significantly produced with 30 days old seedlings, followed by 50 and 40 days old ($P \leq 0.05$)

which were statistically similar; while few number of tillers were produced from 10 days old seedlings. Similar trend was observed at both 8 and 10 WAT in 2021. At 6 WAT in 2021, more tillers were recorded by the 30 days old seedlings, followed by 50 days and 40 days, while the few number of tillers were recorded with the seedlings age of 10 days. At 10 WAT, seedlings age of 30 days significantly produced more tillers than by the seedling age of 20 days, 50 days and 40 days. Fewest tillers ware by the seedling age of 10 days.

Variety on the other hand, showed significant effect with respect to number of tillers in both 2020 and 2021rainy season. In 2020, at 6 WAT, Faro 44 recorded the highest number of tillers followed by Faro 57; while fewest tillers were by variety Faro 52. Similar trend was obtained at both 8 and 10 WAT. In 2021, at 6 WAT, Faro 44 recorded significantly more tillers than both Faro 57 and Faro 52 which were statistically similar. Similar trend was obtained at both 8 and 10 WAT. The age of seedling at transplanting significantly affect the number of productive tillers, this also is inconsistent with the report of Li *eta al*., 2011 this may be ascribed to the ability of the older seedling to recover fast and compete intensively for resources under normal growth conditions,

Leaf Area Index (LAI)

LAI of rice varieties as influenced by seedlings age at transplanting is presented in Table 2. Leaf area is an important plant trait which is directly linked with the rate of photosynthesis and crop yield. Total leaf area present at flowering greatly affects the amount of assimilates available to the panicles (De Datta, 2019). In 2020, at 6 WAT, higher LAI was obtained from the seedlings transplanted at 30 days, than the other seedling ages, while the lowest LAI was by the seedling age of 10 days. Similar trend was observed at 8 and 10 WAT for 2020 and at 6 and 10 WAT in 2021. At 8 WAT in 2021, higher LAI was recorded from seedling age of 30 days, followed by seedling age of 20 days and 40 days, which in turn were higher than the seedling age of 50 days. The lowest LAI was by seedling age of 10 days. Variety showed significant effect with respect to LAI. In 2020 trial, Faro 52 and Faro 44 recorded significantly similar and the highest LAI while Faro 57 recorded the lowest. Similar trend was obtained at 8 and 10 WAT. In 2021 trial, at 6 WAT, Faro 44 had ($P \leq 0.05$) highest LAI, while Faro 52 and Faro 57 recorded similar but lower LAI. A similar trend was obtained at 10 WAT. At 8 WAT, Faro 44 recorded higher ($P \leq 0.05$) LAI, followed by Faro 52, while the lowest LAI was obtained by Faro 57. The interaction of seedling age and variety on LAI was not significant in all the sampling periods at in both years.

Crop Growth Rate ($gm^{-2}wk^{-1}$)

Crop growth rate (CGR) of rice varieties as affected by seedling age is presented in Table 3. In 2020, at 6 WAT, greater CGR was obtained from the seedling age of 30 days, followed by the seedling age of 10, 20 and 40 days which were in turn higher than by seedling age of 50 days. A similar trend was observed in 9 WAT in both 2020 and 2021 trial. But at 6 WAT, in 2021 trial, higher CGR was obtained by the 30 days aged seedlings followed by the other treatments, which were statistically similar.

There was significant difference in CGR among the varieties in both seasons throughout the sampling periods. In 2020 trial, at 6 WAT, higher CGR was recorded by Faro 52 followed by Faro 44, while Faro 57 recorded the lowest CGR. Similar trend was obtained in 9 WAT in both 2020 and 2021 trial. At 6 WAT in 2021 similar and greater CGR was obtained from Faro 52 and Faro 44, while the lowest CGR was recorded with variety Faro 57.

The interaction between the seedling age and variety (Table 8) shows that, the highest CGR was recorded by Faro 52 when transplanted at 30 days, while the lowest CGR was recorded by Faro 44 when transplanted with the seedlings aged 10 days.

Relative Growth Rate ($gg^{-1}m^{-2}wk^{-1}$)

Relative growth rate (RGR) of rice varieties as influenced by seedling age at transplanting is presented in Table 4. In 2020, at 6 WAT, the treatments had no significant effect on RGR. At 9 WAT, higher RGR was recorded by the 30 days old seedling which was at par with those transplanted at 20 and 50 days, and were in turn higher than seedlings transplanted at 10 and 0 days. A similar trend was observed at 9 WAT, in 2020, and throughout the sampling periods in 2021 trial. There was significant difference in RGR due to variety in both 2020 and 2021 throughout the sampling periods. In both 2020 and 2021, at 6 WAT variety did not significantly affect the RGR. At 9 WAT, variety Faro 52 and Faro 57 were similar and significantly higher than Faro 44 in RGR. Similar trend was observed 2021 trial at 9 WAT. But at 6 WAT in 2021, Faro 52 recorded the highest RGR compared with Faro 44 and Faro 57 which were statistically similar. The interaction of seedling age and variety on relative growth rate was not significant throughout the sampling periods in both years.

CONCLUSION

Based on the results of this study, it could be concluded that Faro 57 and Faro 52 out yielded Faro 44. Also, the seedling age of 30 days resulted in the high growth attributes of rice which resulted in higher grain yield.

Table 1:Tiller number of rice varieties as influenced by seedling age during 2020 and 2021 rainy seasons.

Treatment	**Tiller Numbers at 10WAT**	
	2020	**2021**
Seedling Age		
10days	16.78d	17.81c
20days	20.11c	22.81b
30days	26.22a	27.58a
40days	24.11b	21.31b
50days	25.00ab	22.25b
SE±	**1.370**	**1.300**

Variety		
Faro 44	27.93a	28.76a
Faro 52	21.93c	20.12b
Faro 57	23.07b	20.97b
SE±	**1.610**	**1.820**
Interaction		
SA x Var	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using DMRT, NS: not significant at 5% level of significance, *: significant at 5% level of significance. S.A = Seedling age

Table 2: Leaf area index of Rice varieties as influenced by seedling age in 2020 and 2021 rainy season.

Treatment	Leaf Area Index					
	2020			2021		
	6WAT	8WAT	10WAT	6WAT	8WAT	10WAT
Seedling Age (days)						
10	1.12c	2.46c	3.78c	1.09c	2.09d	3.86c
20	2.87b	4.58b	6.11b	1.93b	3.49b	4.71b
30	3.98a	5.89a	7.22a	2.16a	4.87a	6.59a
40	2.94b	4.65b	6.11b	1.72b	3.14b	4.51b
50	2.89b	4.76b	5.10b	1.94b	2.81c	4.95b
SE±	**0.318**	**0.631**	**0.870**	**0.810**	**0.510**	**0.367**
Variety (V)						
Faro 44	3.10a	4.05a	5.93a	2.72a	4.35a	6.79a
Faro 52	3.23a	4.59a	5.93a	1.76b	3.12b	4.72b
Faro 57	2.24b	3.10b	4.07b	1.48b	2.96c	4.27b

SE±	**0.391**	**1.440**	**0.310**	**0.528**	**0.476**	**0.620**
Interaction						
SA x Var	NS	NS	NS	NS	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using DMRT, NS: not significant at 5% level of significance.

Table 3: Crop Growth Rate of Rice varieties as influenced by seedling age 2020 and 2021 during rainy season.

Treatment	Crop Growth Rate (CGR)			
	2020		2021	
	6WAT	9WAT	6WAT	9WAT
Seedling Age (days)				
10	4.37b	7.23b	3.78b	6.97b
20	4.28b	7.98b	3.99ab	7.00b
30	5.09a	9.39a	4.89a	8.03a
40	4.87b	8.50ab	4.00ab	7.43b
50	3.37c	6.78c	3.19b	5.65c
SE±	**0.730**	**0.370**	**0.743**	**0.393**
Variety				
Faro 44	4.85b	8.63b	4.35a	7.46b
Faro 52	5.93a	9.93a	4.99a	8.72a
Faro 57	4.10c	7.55c	3.07b	6.47c
SE±	**0.456**	**0.610**	**0.434**	**0.827**
Interaction				
SSA x Var	NS	NS	NS	*

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using DMRT, NS: not significant at 5% level of significance, *: significant at 5% level of significance.

Table 4: Relative Growth Rate (RGR) of Rice varieties as influenced by seedling age in 2020 and 2021 rainy season.

Treatment	Relative Growth Rate ($gg^{-1}m^{-2}wk^{-1}$)			
	2020		2021	
	6WAT	9WAT	6WAT	9WAT
Seedling Age (days)				
10	0.045	0.078b	0.033b	0.060c
20	0.043	0.106ab	0.034b	0.084b
30	0.040	0.176a	0.056a	0.101a
40	0.042	0.085b	0.038b	0.078b
50	0.048	0.110ab	0.040ab	0.084b
SE±	**0.129**	**0.107**	**0.201**	**0.492**
Variety				
Faro 44	0.040	0.084b	0.038ab	0.087b
Faro 52	0.045	0.180a	0.043a	0.156a
Faro 57	0.042	0.122a	0.033b	0.110a
SE±	**0.098**	**0.102**	**0.118**	**0.201**
Interaction				
SA x Var	NS	NS	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using DMRT, NS: not significant at 5% level of significance.

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Correlation studies on the effects of age of seedling at transplanting on growth and yield parameters of rice (*Oryza sativa* L) varieties.

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ABSTRACT

Field experiments were conducted at the National Cereals Research Institute low land research field Gwadangaji area Birnin Kebbi, kebbbi State (lat. 12°12.99' N; long. 4° 21.90'E; 197m above sea level) during the 2020 and 2021 rainy seasons located in Sudan Savanna ecological zone of Nigeria. The aim of the experiments was to study the response of rice varieties to Seedling age. The treatments consisted of a factorial combination of three rice varieties (Faro44, Faro52 and Faro57) and five (5) seedling age; 10, 20, 30, 40 and 50 days which were laid out in a randomized complete block design (RCBD), replicated three times. The size of each plot was 3 m x 2 m (6m^2). The study reveals that correlation between the grain yield, establishment count (r = 0.382) and panicle lenght (r = 0.394) were positive and weak; that with plant height 6 WAT (r = 0.491), number of panicles (r = 0.511) and 1000-grain weight (r = 0.407) were positive and moderate. On the other hand, correlation between grain yield and LAI 8 WAT (r = -0.576) was moderately negative while that with CGR 9 WAT (r = - 0.209) was negative and weak. In 2021 location, correlation between yield and Plant Height 6WAT (r = 0.341), NP (r = 0.367), panicle lenght (r = 0.375), and 1000-grain weight (r = 0.311) were positive and weak; while that with tiller number (r = -0.789) and LAI 8WAT (r = -0.694) were strongly negative.

Keywords: Rice, Variety, Seedling age, Growth and Yield

INTRODUCTION

Rice belongs to the grass family Poaceae and the genus Oryza. The *Oryza genus* contains about 20 different species of which only two are currently cultivated*; Oryza sativa* and the *Oryza glaberrima* with origin from Asia and Africa, respectively. The species varied in statute, life cycle and adaptation (Maji *et al*., 2014). The plant is not aquatic but substantial amount of water is required for its production, hence it is considered to be semi-aquatic annual (Padhi, 2004). Rice is a staple food for over 50% of the global population making it the most important food crop (More *et al*., 2007). In Nigeria, rice is the highest cherished fastest growing food and cash crop. Its demand is growing faster than any other food crop, and it remains one crop in which Nigeria can easily become food self-sufficient given the potentials that abound in the country in terms of ecology and favourable agro-ecological conditions (Ibrahim *et al.*, 2015). Rice can be utilized as food in many forms, it is mostly served at a social gathering and in performing some traditional rites, the forms includes rice cake, *Masa,* rice dough *Fura* in Hausa, infant food, beverages and snacks. The bye-product has so many uses, rice straw if incorporated into the soil enhances aeration, used as livestock bedding, animal feed and even in mushroom production (Gao *et al.*, 2004). Rice yield in Nigeria is relatively low (1.81t/ha) despite abundant area put to rice production and availability of suitable ecologies and climatic conditions. Despite the availability of improved high yielding varieties farmers still record low yields. This low yield is attributed to poor agronomic practices, particularly the nursery and transplanting procedures. Considering the water requirement for rice production and the cost of pumping water during the dry season, it is pertinent to relate age of seedling at transplanting with days to maturity, as delay in transplanting affects growth and yield. (Mohammed *et al*. 2017). Late transplanting delays maturity compared to early transplanting which results to longer days of irrigation thereby increasing the cost of production. Transplanting rice too late affects root establishment and tillering ability and grain formation which reduces the productivity of rice. (Sarker *et al*., 2012). Varieties vary in their days to maturity so it is very important to determine the appropriate age of seedling at transplanting for each variety. For an effective extension package on rice production in Sudan Savana region like Kebbi State, a scientific knowledge on the most appropriate age of seedling at transplanting for various varieties of rice is necessary.

MATERIAL AND METHOD

Experimental site: The experiment was conducted at fadama field of the National Cereals Research Institute (NCRI) Sub-station, Gwadangaji in Birnin Kebbi Local Government Area of kebbi State, located in the Sudan savanna agro ecological zone of Nigeria. The average annual rainfall of the area ranges from 660 mm – 750 mm per annum. The temperature varied from 22 to 31^{o}C in the rainy season (NiMet, 2019).

Experimental Design: The treatments consisted of three rice varieties (FARO 44, FARO 52 and FARO 57) and five seedling ages (10, 20 30 40 and 50 days old), making a total of fifteen treatment combinations. These were laid out in a Randomized Complete Block Design (RCBD) with three replications. All the rice varieties were collected from the National Cereals Research Institute (NCRI) Badeggi..

Data collection and analysis: Agronomic data were taken from plants in two middle rows of each plot to reduce border effect. Data collected includes; establishment count, plant height, tiller number, crop growth rate, leaf area index, net assimilation rate, and yield parameters (number of panicle per (m^2), panicle length, number of grains per panicle, days to 50% flowering, 1000-grain and grain yield), all data were collected using the standard evaluation system (SES 2013) and were subjected to Analysis of Variance (ANOVA) procedure and means were separated using Duncan's New Multiple Range Test (DNMRT) at 5% level of probability. Pearson's correlation coefficient analysis was carried out to study the relationship among growth and yield parameters.

RESULTS AND DISCUSSION

Result shows correlation coefficient between growth and yield parameters at NCRI Research field Birnin Kebbi during 2020 rainy season.

In 2020, the correlation between the grain yield and establishment count (r = 0.382) and panicle length (r = 0.394) were positive and weak; that with plant height 6 WAT (r = 0.491), number of panicles (r = 0.511) and 1000-grain weight (r = 0.407) were positive and moderate. On the other hand, correlation between grain yield and LAI 8 WAT (r = -0.576) was moderately negative while that with CGR 9 WAT (r = - 0.209) was negative and weak.

In 2021, correlation between yield and Plant Height 6 WAT (r = 0.341), NP (r = 0.367), Panicle Length (r = 0.375), ssand 1000-Grain Weight (r = 0.311) were positive and weak; while that with Tiller Number (r = -0.789) and LAI 8 WAT (r = -0.694) were strongly negative.

CONCLUSION

From this study it was concluded that growth and yield parameters recorded positive correlation among each other, which indicate strong relationship between and within growth parameters. However, the magnitude of growth parameters correlation coefficient was higher than their corresponding yield parameters correlation coefficients, suggesting the importance of age of seedling at transplanting on yield. Generally, traits such as grain yield, tiller number,1000-grain weight are important traits for grain yield in rice.

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Table 1: Correlation matrix among growth and yield characters of rice at NCRI Field during 2020 rainy season.

	1	2	3	4	5	6	7	8	9	10
GY	1.000									
ES CT (%)	0.382*	1.000								
PH6 WAT	0.491*	0.622**	1.000							
TN8 WAT	0.101ns	0.271ns	0.243ns	1.000						

LAI 8WAT	-0.576**	0.199ns	0.117ns	0.319*	1.000					
CGR9WAT	-0.209ns	-0.745**	0.451*	0.199ns	0.145ns	1.000				
RGR9WAT	0.198ns	0.456*	0.378*	0.209ns	0.178ns	0.290ns	1.000			
NP	0.511**	0.117ns	-0.231ns	0.116ns	-0.437*	0.219ns	0.334*	1.000		
PL	0.394*	0.127ns	-0.104ns	0.342*	-0.231ns	0.378*	0.276ns	0.338*	1.000	
1000GW	0.407*	0.567**	0.280ns	0.654**	0.239ns	0.177ns	0.298ns	-0.786**	0.361*	1.000

1.Grain yield/ha, 2. Establishment count (%), 3. Plant height (6WAP), 4. Tiller Number (8WAP), 5. Leaf Area Index (8WAP), 6. Crop growth rate (9WAP), 7. Relative growth rate (9WAT), 8. Number of panicle, 9. Panicle length, 10. 1000-Grain weight, ns= not significant at 5%, *=significant at 5%, **= significant at 1%

Table 2: Correlation matrix among y growth and yield characters of rice at NCRI Field during 2021 rainy season

	1	2	3	4	5	6	7	8	9	10
GY	1.000									
ES CT (%)	0.286ns	1.000								
PH6WAT	0.341*	0.789**	1.000							
TN8WAT	-0.789**	0.117ns	0.226ns	1.000						
LAI8WAT	-0.694**	0.345*	0.367*	-0.945**	1.000					
CGR9WAT	0.119ns	0.260ns	0.261ns	-0.711**	-0.218ns	1.000				
RGR9WAT	0.107ns	-0.657**	0.287ns	0.167ns	0.119ns	0.339*	1.000			

NP	0.367*	0.457*	0.198 ns	-0.109ns	0.567**	-0.198 ns	0.345*	1.000		
PL	0.375*	0.144ns	0.177 ns	0.207ns	0.209ns	0.286 ns	0.240 ns	-0.243 ns	1.000	
1000GW	0.311*	0.277ns	0.267 ns	0.310*	0.105ns	0.102 ns	0.349*	0.451*	-0.493*	1.000

1. Grain yield/ha, 2. Establishment count (%), 3. Plant height (6WAP), 4. Tiller Number (8WAP), 5. Leaf Area Index (8WAP), 6. Crop growth rate (9WAP), 7. Relative growth rate (9WAT), 8. Number of panicle, 9. Panicle length, 10. 1000-Grain weight, ns= not significant at 5%, *=significant at 5%, **= significant at 1%

Incidence and Severity of Fonio (*Digitaria* spp) brown leaf spot (C*urvularia geniculata*) in selected states in Nigeria

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ABSTRACT
A survey of brown leaf spot on fonio (*Digitaria iburua and D. exilis*) was carried out in the major growing areas of Nigeria in 2014 and 2015. The states surveyed were Bauchi, Kaduna, Plateau and Nasarawa. Two visits were made to each state in each of the years (2014 and 2015). In each LGA, three towns were randomly selected and three farms were sampled. With a quadrat, five plots were assessed for disease incidence and severity in all the farms visited. In 2014, there were significant ($P \leq 0.05$) differences in incidence of brown leaf spot in all areas visited. The highest incidence (48.06%) of brown leaf spot was recorded in Zawang in Plateau state which was not significantly different from all other locations except, Nahuta and Bogoro (Bauchi) which had the least incidence (22.0 and 20.30 %). In 2015, the incidence of brown leaf spot was also highest (55.13%) in Zawang (Plateau state) and Kwaturu, in Kaduna state. Angware, Demank, Mbar, Munguna, Nyeleng (Plateau state) and Bogoro, Nahuta Gyara (Bauchi state) had the least incidence. There was no significant ($P \leq 0.05$) difference in brown leaf spot severity in all the locations in both years. The disease was more prevalent in Plateau and Kaduna States.

INTRODUCTION
Fonio (*Acha*) or hungry rice (*Digitaria exilis* and *Digitaria iburua*) originated in West Africa and is a grain crop cultivated for centuries across fifteen countries in the Northwest Africa from Cape Verde Island to Chad, Ivory Coast and Cameroon (Jideani, 1999). Fonio is the most ecologically adapted and economically useful species of the monocotyledons (Anon. 1996; Cruz, 2004) due to its ability to grow under marginal rainfall and low inputs. However, it is underutilized and neglected in Africa (Anon. 1996). It has the potential to improve nutrition, boost food security, foster rural development and support sustainable use of land. It is grown in the central and northern

states of Nigeria, particularly in Bauchi, Kaduna, Kebbi, Nasarawa and Plateau states where it is locally called 'Acha' (Aliero and Morakinyo, 2001). The three largest producers are Guinea, Nigeria and Cote d' Ivoire with production of 500, 986, 82, 750 and 19, 263 tons from 466, 622, 190, 315 and 33, 983 ha, respectively (FAO, 2016).

Both *Digitaria* species have been reported to be susceptible to insect pests and diseases (Vietmeyer *et al.*, 1996; Kwon-Ndung and Misari, 1999), thus, contributing to low yield. There is a paucity of information on the diseases of fonio in Nigeria (Auta, 1983). The first incidence was reported in Samaru, Zaria, where leaf blast (*Pyricularia* sp) and leaf spot (*Helminthosporium* sp) were identified on fonio plants (Auta, 1983). Therefore, the objective of this study is to determine the occurrence and distribution of brown leaf spot on fonio in the major growing areas in Nigeria.

MATERIALS AND METHODS

A survey of brown leaf spot of fonio (*Digitaria iburua and exilis*) was carried out in the growing areas of Nigeria between the second week of July and last week of August, 2014 and 2015. The producing states surveyed were Bauchi, Kaduna, Plateau and Nasarawa states. Two visits each were made to each state in 2014 and 2015. Two Local Government Areas (LGAs) were surveyed in Bauchi (Bogoro and Tafawa Balewa), three in Kaduna (Jabba, Kachia and Kagarko), ten in Plateau (Barkin Ladi, Bassa, Bokkos, Jos East, Jos South, Kanke, Mangu, Pankshin, Quanpan and Riyom) and one in Nasarwa State (Wamba). In each LGA, three selected towns and three farms were sampled with a farm taken as a replicate. Using a quadrat of 30x 30 cm, five plots of about a hectare and three farms of less than a hectare were surveyed/. Disease assessment was based on macroscopic symptoms characteristic of fonia brown leaf infection which are usually brown pin sized lesions of less than 0.1mm in diameter around the lower leaves which later enlarges becomes dark red and form numerous spots of about 0.1-0.3 mm. In advanced cases lesions coalesced to form blight along leaf margin and towards the leaf tip leading to wilting of leaves.

Disease incidence was estimated by counting the number of infected plants in each plot and expressing this as a percentage of the total number of plants in the plot (Tarr, 1981).

$$DI=\frac{Number\ od\ individual\ diseased\ plants}{Total\ number\ of\ plants}\ X\ 100$$

For disease severity assessment, individual plants within the sampling plot were scored on a rating scale of 1 – 5, according to Tarr, 1981, where; 1=No spots on leaves, 2= 1-25 % of leaves with spots, 3= 26-50 % of leaves with spots, 4= 51-75 % of leaves with spots and 5= 76% and above leaves with spots. The disease severity was calculated using the formula below as expressed in percentage:

$$DS=\sum\frac{Nx}{N(5)}$$

where; $\sum$ = Sum total, x = disease rating grade, n = number of plants per given grade, N= total number of plants examined per plot and 5= the maximum disease grade. Data collected were subjected to analysis of variance using SAS (2013) and means compared using the Student Newman Keuls (SNK) test at 5 % level of significance.

RESULTS

Acha growing locations in the major producing states and the level of brown leaf spot infection is presented in Figure 1. Geographically, the study area stretches between latitude $9^{0}0^{1}0^{11}$ N - $11^{0}0^{1}0^{11}$ N of the equator and between Longitude $8^{0}0^{1}0^{11}$E – $10^{0}\ 0^{1}\ 0^{11}$ E of the Greenwich Meridian covering Bauchi, Kaduna, Nasarawa and Plateau States (Fig 1). Areas with 20-30 % severity were grouped as low severity, 30.1-40 % moderate severity while above 40 % high severity (Figure 1.)

The result of the various locations visited is presented in Table 1. In 2014, the highest incidence of brown leaf spot was recorded in Zawang (48.06%) which was not significantly ($P \leq 0.05$) different from all other locations except Nahuta and Bogoro (22.30 and 20.36%) which had the least incidence. In 2015, the incidence of brown leaf spot disease was also highest in Zawang (55.13%) in Plateau state and Kwaturu (54.33%) in Bauchi state, however, this significantly ($P \leq 0.05$) varied with only Angware, Bogoro, Demank, Mbar, Nahuta, Munguna, Nyeleng and Gyara which had the least incidence that was not significantly different from other locations. There were no significant ($P \leq 0.05$) differences in brown leaf spot severity in all the locations visited.

In 2014, the incidence of brown leaf spot was highest in Plateau state (33.20 %) but was not significantly ($P \leq 0.05$) different from locations in Kaduna state. The least incidence was recorded in Bauchi state (27.5) and this was at par with Nasarawa and Plateau states. However, in 2015 Kaduna state (42.7) had the highest incidence which did not vary from locations in Plateau state while Bauchi (28.1 %) had the least incidence (Figure 2). For severity of brown leaf spot, Nasarawa state (31.0%) recorded the highest severity which did not differ from other locations in Plateau state while the least severity was observed in Kaduna state (29.2%) during 2014 cropping season. In 2015, Kaduna state recorded the highest severity (28.5 %) (Figure 3).

DISCUSSION

The disease was more prevalent in all the locations in Kaduna and Plateau states than Bogoro and Nahuta in Bauchi State. The reason could be due to differences in agro ecological zones and variation in weather parameters which in some case might not have been favourable for the pathogen. Weather factors play a major role in the initiation of disease and each pathogen has its own optimum requirement for infection (Hardwick, 2002). High temperature and frequent rainfall have been reported to favour blight of Zoysia grass (*Curvularia inaequalis*) in China (Kim *et al.*, 2000). The average rainfall recorded in Kaduna state during the survey (August 2015) was 284 mm while the temperature ranged from 24.5-29 ^{0}C. Plateau state had an average rainfall 308.6 mm in August and temperature of 24.5-27 ^{0}C These could have accounted for the prevalence of the disease in Plateau and Kaduna states compared to Bauchi state with an average rainfall of -252 mm and temperature of 29 ^{0}C. Bauchi has drier days than Plateau and Kaduna states. Bawa (1992) reported the influence of weather on the spread and development of midrib disease of millet. In the report, it was discovered that Jibia in far north had lower disease incidence than Sokoto and

Katsina, and this was attributed to the effect of hot dry weather which slows the rate of disease development. The differences in disease spread observed on the fonio fields could also be attributed to differences in the time of planting; while some fields were planted at the onset of rains, others were planted later in the season, thereby making infection period to vary in different locations during the survey.

CONCLUSION

Brown leaf spot was found in all the fonio growing areas visited with higher incidences and severity recorded in Kaduna and Plateau states.

Table 1: Incidence and Severity of fonio Brown leaf spot in surveyed location

	Disease incidence (%)		Disease severity (%)		
States/Locations	2014	2015	2014	2015	Fonio type
Bauchi					
T/ Balewa	24.46ab	29.30abc	24.3	33.6	*exilis*
Sara	30.00ab	34.00abc	28.0	42.6	*exilis*
Boi	27.60ab	30.67abc	28.1	34.6	*exilis*
Nahuta	22.30b	21.13c	26.3	31.3	*exilis*
Gyara	29.60ab	24.40c	27.0	44.0	*exilis*
Bogoro	20.36b	23.70c	25.7	33.3	*exilis*
Kaduna					
Ungwan Waje	31.87ab	39.06abc	25.7	32.6	*iburua*
Sada bege	36.30ab	44.83abc	24.7	36.0	*exilis*
Kurmin Bauna	25.46ab	40.00abc	28.1	37.3	*iburua*
Kurmin Jatau	29.13ab	34.10abc	28.3	32.0	*exilis*
Kurmin Jibrin	30.08ab	32.10abc	27.7	43.6	*exilis*
Kwaturu	34.83ab	54.33a	28.1	40.0	*exilis*
Kenye	29.03ab	43.46abc	24.0	31.0	*exilis*
Dura	42.66ab	43.00abc	46.6	50.7	*iburua*
Fai	37.76ab	44.97abc	31.7	50.6	*exilis*
Nasarawa					
Arum	28.60ab	36.03abc	27.3	34.6	*exilis*
Chigbo	30.20ab	32.10abc	35.3	43.6	*exilis*
Wamba	33.06ab	35.50abc	30.1	30.2	*exilis*
Plateau					
Demak	28.03ab	27.00bc	27.1	37.0	*iburua*
Doi	28.50ab	33.07abc	24.0	38.3	*exilis*
Du	39.46ab	40.06abc	31.6	48.6	*exilis*
Federe	31.76ab	32.40abc	27.0	36.0	*exilis*

Fir	33.80ab	39.80abc	26.7	44.0	*exilis*
Fobur	38.36ab	52.100ab	27.7	45.7	*exilis*
Foron	31.54ab	38.63abc	30.3	39.3	*exilis*
Ganawuri	37.00ab	47.07abc	34.3	34.3	*iburua*
Garam	28.93ab	29.80abc	32.6	37.7	*iburua*
Gindiri	33.03ab	31.70abc	30.6	34.0	*iburua*
Gotaop	37.06ab	42.67abc	33.6	43.0	*iburua*
Angware	26.76ab	25.90bc	30.0	40.6	*iburua*
Balang shipen	28.96ab	37.30abc	31.3	35.3	*iburua*
Heipang	35.43ab	37.30abc	30.0	36.6	*exilis*
Jipal	33.40ab	38.33abc	32.0	41.0	*iburua*
Koronfang	42.23ab	41.23abc	32.0	45.8	*iburua*
Lardang	29.06ab	35.80abc	37.0	41.3	*exilis*
Lato'ok	28.66ab	32.90abc	31.7	45.0	*iburua*
Lemoro	41.57ab	40.47abc	31.1	40.6	*iburua*
Mangun	43.33ab	33.40abc	26.7	37.6	*exilis*
Mbar	29.10ab	27.73bc	31.3	37.6	*exilis*
Miango	38.66ab	43.87abc	28.1	34.3	*exilis*
Munguna	31.33ab	27.100bc	36.0	38.6	*exilis*
Nyeleng	25.83ab	22.01c	26.0	32.3	*iburua*
Rukuba	36.46ab	34.100abc	29.6	34.7	*exilis*
Shiwer	27.03ab	40.36abc	32.0	40.0	*iburua*
Sho	33.36ab	36.00abc	30.0	37.6	*exilis*
Ta – hoss	29.13ab	42.00abc	29.1	39.0	*exilis*
Tof	28.96ab	28.73ab	20.7	31.6	*iburua*
Zawang	48.06a	55.13a	36.6	41.3	*exilis*
SE ±	44.221	93.686	0. 02	0.06	
Interactions (Mnths)					
July	45.596b	38.01b	39.4b	40.1b	
August	60.69a	60.26a	50.8a	57.3a	
SE ±	15.11	22.25	11.3	7.2	

Means followed by the same letter in each column are not statistically different ($P \leq 0.05$) according to Student Newman Keuls (SNK) Test

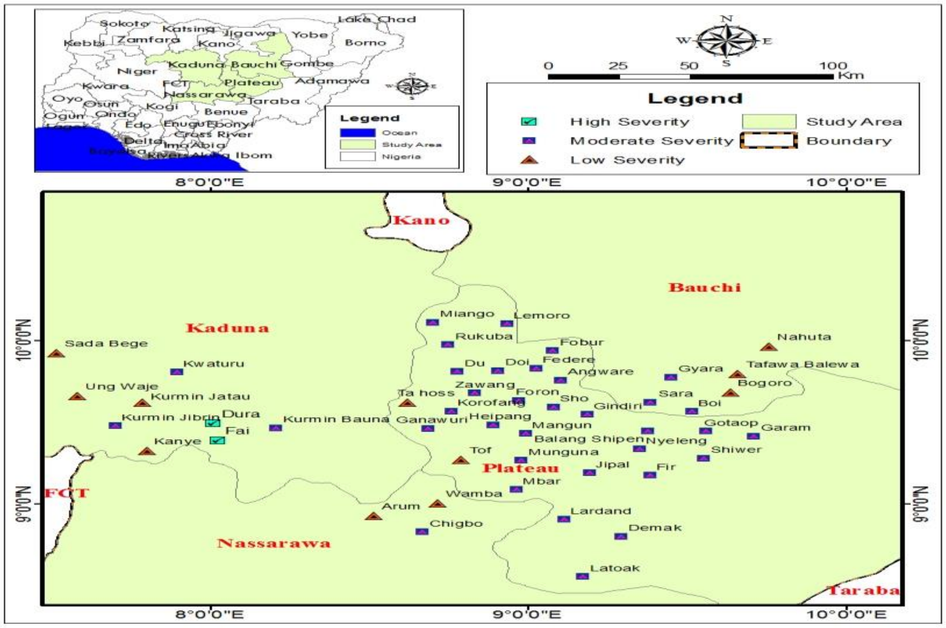

Figure 1: Distribution of Brown leaf spot in the surveyed areas

Key:

20- 30 % - Low severity

30.1-40 % - Moderate severity

> 40 %   - High severity

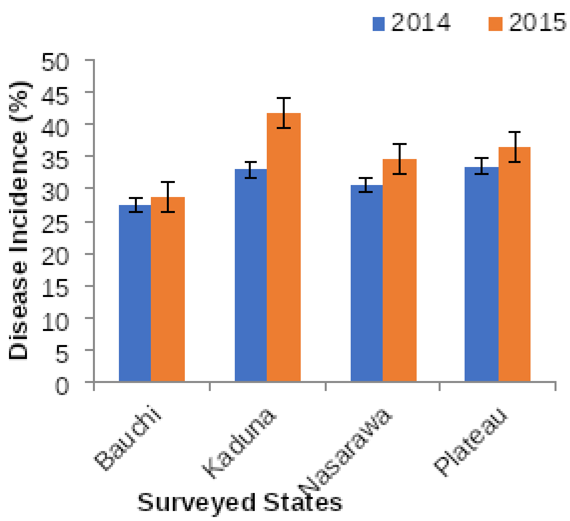

Figure 2: Incidence of brown leaf spot in surveyed states in Nigeria

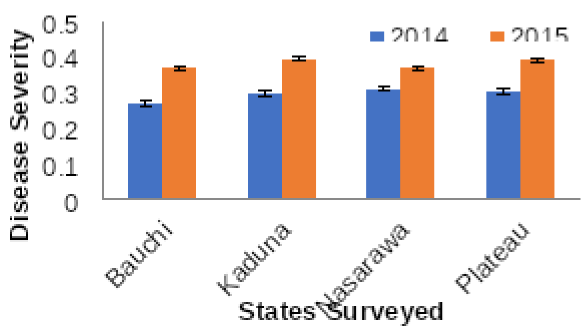

Figure 3: Severity of brown leaf spot in surveyed states in Nigeria

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Response Of Soil Microbial Community (Bacteria And Fungi) To Organic And Inorganic Amendments Using Tomato As A Test Crop

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ABSTRACT

A field experiment was conducted to evaluate the response of soil microorganisms (bacteria and fungi), to some soil amendments (organic and inorganic). The experiments were laid out in randomize complete block design (RCBD). The treatments applied were compost (3.4t/ha), poultry manure (4.2t/ha), *Tithonia diversifolia* (4.8t/ha), NPK (15:15:15) (0.8t/ha) at 120kg N/ ha and the control. Treatments were replicated three times. Soil microbiome (Fungi and Bacteria were estimated using standard laboratory methods. Data collected were subjected to statistical analysis. Compost improved both the total number and diversity of fungi than other amendments while diversity of bacteria was increased more by poultry manure and *Tithonia diversifolia* than the other amendments studied. Compost had the highest percentage (25.8%) of bacteria suppressed than other amendment studied. *Tithonia diversifolia* enhanced the growth of bacteria the most (16.7%) while NPK had the highest reduction of bacteria growth (31.6%). *Tithonia diversifolia* had the highest percentage of proliferation of allochtonus bacteria (27.7%). Percentage of suppressed fungi was the highest in *Tithonia diversifolia* (28.2%). Fungi growth was more enhanced in un-amended plot (66.7%) while poultry manure had the highest percentage of fungi growth reduction (26.1%). Poultry manure and *Tithonia diversifolia* had the highest percentage of proliferation of allochtonus fungi (25.5%). application of compost, poultry manure and *Tithonia diversifolia* are recommended for the improvement of soil microbial properties.

Keywords: Tomato, Soil fungi, Soil bacteria, organic amendment Allochtonous and Soil microbial properties.

INTRODUCTION

Over the years, the idea of practicing intensive agriculture is to achieve high productivity however; this practice had adversely affected soil health and biodiversity despite the remarkable increases in overall food production (Tuğrul, 2019). Long-term usage of inorganic fertilizers causes soil, water and environmental pollution, food insecurity, development of pathogen/pest resistance, residual toxicity towards micro and macro organisms and loss of biodiversity (Ruano-Rosa and Mercado-Blanco, 2015). This therefore necessitated the need for eco and human health friendly, sustainable and alternative farming practice.

Organic farming is a sustainable and affordable system which strictly prohibits the use of synthetic fertilizers thereby reducing the negative effect of chemical fertilization (Chaney and Ramsubhag, 2017; Ye et al, 2020). It's one of the oldest ways of practicing sustainability in agriculture (Faissal et al., 2017). Application of organic amendments such as compost, plant debris, animal manure, peat moss and organic mulch increase the organic matter content of the soil. It's also a major substrate in management of soil and plant health as well as suppression of diseases resulted from soil borne pathogens. The organic matter content of soil is use to determine soil health as it governs the physical, chemical and biological properties of soil (Gómez-Sagasti et al., 2018). It has been reported that presence of soil organic matter can reduce bulk density and increase water holding capacity and soil aggregate stability (Gómez-Sagasti et al., 2018). Organic matter supply microorganisms with essential nutrients (Reeve et al. 2016) therefore increase the microbial population, catalyze their activity (Larkin, 2015), allows high biodiversity (Turmel et al., 2015). As stated by Chandrashekara and Bhatt (2014) and Scotti et al. (2015) organic matter aids natural disease suppression and soil fertility thereby improving soil health.

Compost as a type of organic amendment has been known to improve the growth and yield of plant by improving the physio-chemical properties of soil hence enhance nutrient availability (Chaney and Ramsubhag, 2017).

Soil can be enriched through the incorporation of green manures (Larkin, 2013) which is an important alternative source of organic fertilizers (Hafifah et al., 2016). Green manure has lot of benefit in the soil, which ranges from soil organic carbon enhancement, soil health improvement, high agronomic productivity (Hafifah et al. 2016), soil microbial biomass and activity enhancement (Larkin, 2013).

Tithonia (*Tithonia diversifolia*) from Asteraceae family used as green manure due to its high nutritional composition, has proved effective in improving soil fertility (Hafifah et al., 2016), physical properties of soil (Hafifah et al., 2016; Dayo-Olagbende et al., 2020) and crop yield (Babajide et al., 2012).

The role of microorganisms is vital in the ecosystem; however, the method of intensive agricultural does not support their healthy population which could result in low productivity (Christopher Johns, 2017). Soil microorganisms are involved in many biogeochemical processes of the soil. Soil microbes are important to life as they play a pivotal role in nutrient cycling and responsible for the biological fertility of the soil (Christopher Johns, 2017). They are great determinant for soil performance through decomposition of plant materials and residues to increase the organic matter content of soil, thereby improving the soil quality (Faissal et al., 2017).

There has been well documented information on how organic amendments improve soil fertility and productivity. More also, research results shows that the use of synthetic chemicals (fertilizers, pesticides, herbicides) results in toxic residues in food; enhance environmental pollution and eliminate non-target organisms from the ecosystem. There is need to study the response of soil microorganisms to some soil organic amendments since soil microorganisms are important energy transformers and nutrient regulator in agro-ecosystems.

This research therefore aimed at assessing the response of the soil microbial community (bacteria and fungi) to some soil organic and inorganic soil amendments in an alfisol cropped with tomato.

MATERIALS AND METHODS

Experimental Site:

The experiment was conducted at the staff quarters of Landmark University, Omu-Aran, Kwara State, Nigeria with coordinates Latitude 08^o 12107' N and Longitude 05^o 08915' E. The area's annual rainfall ranges from 600 - 1,500mm. The chemical characteristics of the soil is as indicated in table 1.

Table 1: Initial properties of study sites prior to planting

SOIL PARAMETERS	SITE A	SITE B
pH in H_20	5.3b	7.3a
pH in $CaCl_2$	5.2b	6.5a
Exchangeable acidity(cmol/ kg)	2.9a	1.6b
Organic carbon (%)	1.1b	1.6a
Organic matter (%)	1.8b	2.8a
Phosphorus (mg/kg)	7.6b	24.5a
Calcium (cmol/kg)	3.0a	2.7b
Magnesium (cmol/kg)	1.3b	2.7a

Sodium (cmol/kg)	0.1a	0.01b
Potassium (cmol/kg)	0.12b	0.18a
Bulk density (g/cm^3)	1.53a	1.51b
Moisture content (%)	12.0b	14.0a
Porosity (%)	35.5b	36.2a
Particle size distribution		
Sand (%)	81.12	90.6
Silt (%)	7.0	4.0
Clay (%)	11.88	5.4
Textural class	Sandy loam	Sandy

Experimental layout and design

The study adopted randomized complete block design (RCBD) with three replications. The five soil amendments include compost, poultry manure, *Tithonia diversifolia,* inorganic fertilizer (NPK: 15:15:15) and control. The experimental site consists of 15 plots with each measuring 1 × 1m and 0.5 m alley separating each of the plots.

Sources of organic amendments

The compost used was purchased from Institute of Agricultural Research and Training (IART) in Ibadan, poultry manure was collected from the poultry section of Landmark University Teaching and Research Farm, *Tithonia diversifolia* was collected from Landmark University Teaching and Research Farm and inorganic fertilizer (NPK: 15:15:15) was purchased from agro-allied store Omu-Aran, Kwara state.

Land preparation, manure incorporation, seed sowing and fertilizer application

Beds were prepared using hoe. Experimental sites were laid out in 1 × 1 m plot sizes. Organic amendments were incorporated at rate of 120kg N/ha using a hoe to a depth of 20 cm approximately. The weight of each amendment applied were compost (3.4t/ha), poultry manure (4.2t/ha), *Tithonia diversifolia* (4.8t/ha) and NPK (0.8t/ha). Before land preparation the tomato seeds were raised in the nursery at a temperature of about 23 ^{0}C and watered daily. The plots were permitted for mineralization of amendments before seedlings were transplanted. Transplanting was carried out at cool hours of the day and each seedling was transplanted with some soil beneath to reduce damage on the seedling roots (Adekiya, 2019). Each seedling were transplanted at a spacing of 50 × 50 cm. NPK fertilizer was applied 10cm away from the seedlings a week after transplanting employing the side placement method. Manual weeding was done at interval of 3 weeks after transplanting and the tomato plants were staked at fifth week after transplanting.

Tomato Seed Variety: The variety used for the experiment was Roman

Soil sampling and laboratory analysis

Soil sample was obtained from the study site at o-15cm depth before and after the experiment. Soil pH was determined with an electronic soil pH meter (Model 215, Colorado, U.S.A.); soil particle size was analysed using the hydrometer method (Gee and Or 2002); organic matter content was determined using the wet oxidation method (Shamshuddin et al. 1994); exchangeable bases (K, Mg, Na, and Ca), were determined by ammonium acetate method (Chapman 1965).

Organic amendment analysis

Samples of organic amendments (compost manure, poultry manure and green manure) were taken for laboratory analysis. Chemical properties of amendments used are as stated in table 2

Table 2: Chemical component of the organic amendments used for the study

PARAMETERS	COMPOST	POULTRY MANURE	*TITHONIA DIVERSIFOLIA*
Organic carbon (%)	52.0a	26.4b	17.4c
Nitrogen (%)	3.5a	2.9b	2.5c
Calcium (cmol/kg)	2.7a	1.5c	1.7b
Magnesium (cmol/kg)	4.9c	5.7b	11.3a
Sodium (cmol/kg)	0.01a	0.01a	0.01a

Potassium (cmol/kg)	0.4a	0.3b	0.3b

Microbial analysis

Samples collected after the experiment into polythene bag at random using soil auger and transported to the laboratory for microbial count. The standard plate count agar method was employed. Isolation of bacteria and fungi were done using Potato Dextrose Agar (PDA) and Nutrient Agar (NA) respectively. Fungi and bacteria population were estimated using the 6-fold serial dilution method. The pour plate technique was used to culture fungi and bacteria from 10^{-3} and 10^{-5}soil dilutions respectively. Incubation of PDA and NA were done at 37^{0}c for 3-5 days and 24 hours at 28^{0}c respectively. Thereafter; colony-forming units were counted. The frequencies of occurrence of isolates were then calculated.

RESULTS AND DISCUSSION

Response of soil microbial diversity and total number (bacteria and fungi) to organic and inorganic amendments

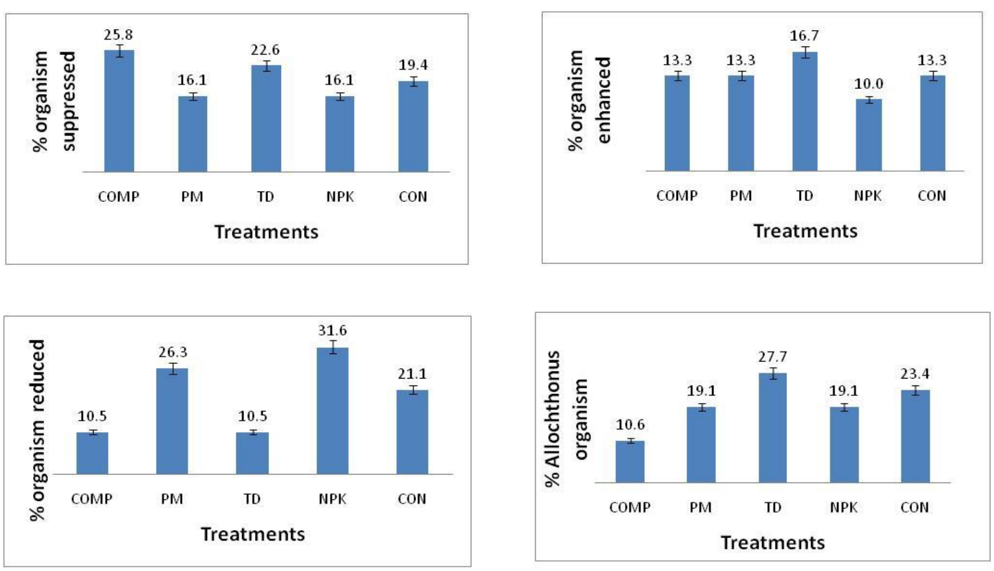
Table 3 shows that all the treatments had greater diversity of bacteria and fungi (ranges from 18-20 and 17-21) than initial (14 and 16) except compost and control that were 11 and 16 respectively. All treatments also had greater total number of bacteria (ranging from 368-1406) than initial (316) except *Tithonia diversifolia* (228) and fungi ranges from 101 – 215 while the total number of the initial was 76. *Tithonia diversifolia* had the highest diversity of bacteria (20), followed by control (19), followed by poultry manure (18) and followed by compost which had the lowest diversity (11) while NPK had the highest diversity of fungi (21), followed by compost (19), followed by poultry manure (18), followed by *Tithonia diversifolia* (17) and control had the least (16). The total number of fungi is in the order of compost (215) > NPK (165) > poultry manure (146) >*Tithonia diversifolia* (125) > control (101) and the total number of bacteria is in the order of poultry

Table 3: Response of soil microbial diversity and total number (bacteria and fungi) to organic and inorganic amendments in the two study sites

TREATMENTS	DIVERSITY OF BACTERIA	TOTAL NUMBER OF BACTERIA	DIVERSITY OF FUNGI	TOTAL NUMBER OF FUNGI
Compost	11	368	19	215
Poultry manure	18	1406	18	146
Tithonia diversifolia	20	228	17	125
NPK	18	868	21	165
Control	19	991	16	101
Initial	14	319	16	76

Response of soil bacteria to the organic and inorganic amendments

Compost (25.8%) had the highest suppression of bacteria site B followed by *Tithonia diversifolia* (22.6%), followed by control (19.4%) and followed by poultry manure and NPK (16.1%). Compost, poultry manure and control enhanced the percentage of bacteria by 13.3% while *Tithonia diversifolia* and control enhanced the percentage of bacteria by 16.7% and 10%. Compost and *Tithonia diversifolia* reduced the percentage of bacteria present initially in the soil by 10.5%, control by 21.1%, poultry manure by 26.3% and NPK by 31.6%. *Tithonia diversifolia* (27.7%) had the highest percentage of bacteria Allochthonus to the soil followed by control (23.4%), followed by poultry manure and NPK (19.1%) and compost (10.6%).

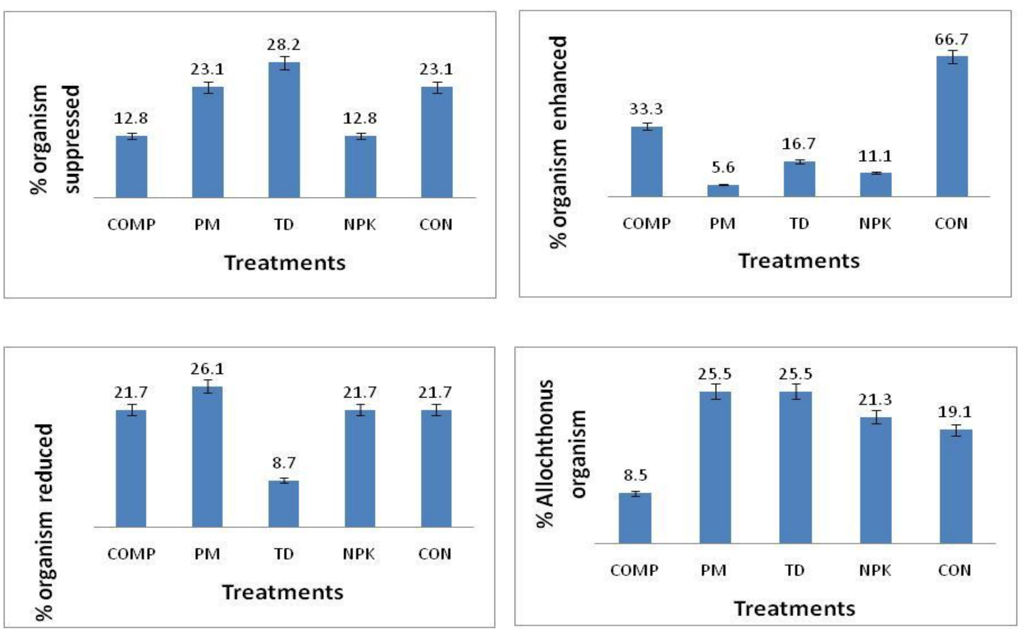


COMP- compost, PM- poultry manure, TD- *Tithonia divesifolia*, CON- control

Fig 3: Response of soil bacteria to the organic and inorganic amendments

Response of soil fungi to the organic and inorganic amendments

The increasing order of fungi suppressed in site B is compost and NPK (12.8%), poultry manure and control (23.1%), and *Tithonia diversifolia* (28.2%). The decreasing order of fungi enhanced is poultry manure (5.6%), NPK (11.7%), *Tithonia diversifolia* (16.7%), compost (33.3%) and control (66.7%). The percentage of fungi reduced by poultry manure was 26.1% while, compost, NPK and control were 21.7% and *Tithonia diversifolia* had the lowest reduction 8.7%. The increasing orders of Allochthonus fungi are compost (8.5%), control (19.1%), NPK (21.3%), poultry manure (25.5%) and *Tithonia diversifolia* (25.5%).



COMP- compost, PM- poultry manure, TD- *Tithonia divesifolia*, CON- control

Fig 4: Response of soil bacteria to the organic and inorganic amendments

DISCUSSION

All treatments increased both diversity of organisms and total numbers of organisms compare to initial, as well as control. Organic amendments enhance organic matter of soil thereby providing nutrients and energy to soil which make the soil a favorable environment for crops growth and microorganism proliferation (Ansari et al., 2019). Poultry litters are important for functional and structural diversity of microbial populations (Mierzwa-Hersztek et al., 2018). Application of poultry manure increased the microbial biomass and significantly influences the activity of nitrifying bacterial in the soil (Mierzwa-Hersztek et al., 2018). Control despite not amended the number of bacteria and its diversity increased which shows that the crop planted had beneficial effect on the bacterial community through root exudates. Nazir et al., (2016) further stressed that root exudates is an important factor which serves as food source for soil microbes and play pivotal role in the interaction of plant and soil microbe.

The amendments affected the diversity and number of fungi presents in study site. The biotic and abiotic characteristic of compost in soil is an indicator for high soil quality (Luo et al., 2021). According to Luo et al., (2021) study, most bacteria and fungi were detected after the incorporation of compost. High fungi diversity in poultry manure and *Tithonia diversifolia* treated plot is as a result of organic matter richness. In addition, changes in fungi was noticed when soil was amended with poultry manure (Abdullahi et al., 2013). Fungi diversity in NPK treated plots is higher and this shows that fungi are sensitive to mineral fertilizer because it has highest diversity in study site. This result correlates with Zhong et al., (2009) who found higher amounts of fungal PLFA in NPK treated soil. Soil microbes are involved in many biogeochemical processes of the soil (Christopher Johns, 2017). Soil microbial biomass and different community structures in soil will increase with organic fertilization (Francioli et al., 2016). Higher nutritional component of compost has been reported by various researches which can be supporting the growth of the encountered organisms (Antoniou et al., 2017). Some treatments suppressed the growth of some organisms which could be associated to antagonistic effect of the treatment or the treatments and tomato plant do not support the growth and proliferation of these organisms. Antoniou et al. (2017) indicated that microorganisms that grow from compost are either characterized with disease suppressing organisms or beneficial organisms. Growth of some pathogenic fungi can be reduced in the soil during mineralization of fresh poultry manure in the soil which results in high heat production through ammonia (Shaji et al., 2021). Some organisms were enhanced in the treated and control plots which were not present in the initial sample. This could be due to microbial and plant exudates or they were either slow growing organisms whose growths were only enhanced by treatment and root exudates or they were foreign organisms introduced by the treatments. According to Bahramisharif and Rose, (2019), organic amendments release organic matter into the soil thereby increasing the microbial biomass, microbial activity and production of polysaccharides in the soil. Plant root exudates are crucial for plant growth by releasing nutrients, changing of soil pH and enhancement of some microbial diversity and activities (Antoniou et al., 2017). Some organism occurred only in the initial samples. This could be as a result of nutrient consumption by the plant in control and/or as a result of microbial and plant exudates. This could also imply that all the treatments and tomato plant do not support the growth and proliferation of these organisms. Some organisms occurred only in a treatment. The occurrence of different organism in these treatments could be as a result of chemical composition difference of the treatments. For instance, it was stated in Zhong et al., (2009) that fungi are sensitive to mineral fertilizers. Some organism occurred only in control and this shows that root exudates supports the growth of microorganisms in the soil. According to Antoniou et al., (2017) plant root exudates are important for plant growth and improving soil quality by releasing nutrients, changing of soil pH and enhancement of some microbial diversity and activities. Moreover, correlating this observation to disease incidence and severity, this shows why compost as well as poultry manure has the lowest disease incidence and severity.

Compost significantly increased the organic carbon of soil and this could high organic matter value of compost as recorded in table 2. Soil organic carbon promotes soil biological properties like nutrient cycling and microbial enhancement as well as soil structure, aeration, water drainage and retention there by reducing soil risk to erosion and nutrient leaching (Corning et al., 2016). This also explains why compost had the highest significant value of total fungi in study site.

Conclusion

Compost improves both the total number and diversity of fungi than other amendments while diversity of bacteria was improved more by poultry manure and *Tithonia diversifolia* and other amendments studied. To improve microbial properties of soil, compost, poultry manure and *Tithonia diversifolia* are recommended.

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Development Of Cassava Varieties With Marginal Unutrient Requirments

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ABSTRACT
Breeding of cassava had focused on the use of agro chemical and commercialization. But the needs of resource-poor farms, marginal areas and organic products cannot be over looked. Currently a breeding Programme was carried out focusing on development and selection of cassava varieties that will yield their potential with little application of external input and those varieties that can give appreciable yield without the application of any external input (agro-chemicals), and improve our degraded soils. An experiment was carried out in NRCRI.UMUDIKE using the combination of organic manure and inorganic fertilizer tested on nine newly developed cassava genotypes and one control to select at less one or two genotypes capable of meeting the above aims. Three treatments consisted of 200kg/h of NPK fertilizer, combination of 5tons of poultry manure and half rate 200kg/h NPK fertilize and 0kg/h application as control were used. This result revealed that genotype V5T1(37t) gave the highest yield and can be recommended for resource poor farmers, followed by V4T2(36t/h)followed can be recommended for poor soils and resource farmers, whileV3T3 and V7T3 are selected for farmers who can afford external input.

INTRODUCTION
Cassava (manihot esculenta crantz) is an important food and industrial crop worldwide, it has a less production cost per unit output than other major staples such as yam, cocoyam etc and capable of growing and giving reasonable yields in low fertile and poor soils (Adeji et al 2005 and stones,2002). Still to get higher yield and greater economic benefits, the crop requires good management and addition of some external inputs. Ekeoro et al (2009) , however observed increase in cassava yield with the use of improved varieties and the addition of external inputs such as agro-chemicals including organic fertilizer comprising macro and micro nutrients, herbicides and pesticides. According to FAO,(2013), Nigeria is the largest producer of cassava in the world with production yield of 52.4 metric tons annually, but with a wide gap between farmers yield of (12h/ha) and actual yield of (50t/ha).The increasing demand for cassava as a staple food for millions of people is increasing at (2%) for food and 1.6% for industrial and animal feed (1.6%) (Dixon, 2003and Nweke, 2004;), and the use of cassavas for ethanol production, (Olumide, 2004), cannot be met with this low yield rate of farmers since more than 90% of cassava producers in Nigeria and Africa belong to the low income class who cannot afford the high cost of these external inputs -agro-chemicals (Mailumo et al, 2012). More so increasing marginal soils caused by degradation, deforestation and reduced fallow system period which have reduced the inherit soil fertility needed for production without the addition of external input has affected

cassava yield and productivity adversely .In Nigeria, different rates of inorganic fertilizer are used by farmers not really adopting fully the recommended rate due to financial constraint and non avaliabity of those inputs. While the facts remains that the recommended rate of NPk fertilizer is 400 kg per hectare for increase yield and 10 tons of organic manure to ameliorate the degradation of soil for enhanced crop yield. This study therefore aims at developing cassava genotypes which will use the soil inherent nutrients or the addition l of minimal input to give optimal yield.

MATERIALS AND METHODS:

The experiment was conducted at NRCRI umudike in the 2019 cropping season. The site is located at 7^o32^e, 50^o29^n and 122m above sea level. The soil is characterized by sandy loamy and medium fertility. Nine newly developed cassava genotypes and three levels of treatments: (half rate of NPK fertilizer 200kg, combination of half level of NPK 200kg/ha and half level of organic manure –poultry manure 5ha and zero level additional input) as against the recommended rates (400kg NPK and 10tons of poultry) respectively. A control which is additional of no external input was used for comparism. The experiment was laid out in 4mX5m factorial randomized complete block design, replicated 3 times. The cassava genotypes were planted at a spacing of 1m X 1m in a plot size of 20m. The treatment was applied 8 weeks after planting. The field was kept weed free by manual weeding and under brushing. Primary data were collected on growth and yield parameters such as harvest index, biomass, number of large roots and total fresh root weight at 12 months after planting. The data collected were analyzed using spss statistical tool version and significant difference was determined and separated by using Duncan multiple range

RESULT AND DISCUSSION:

result of analysis of variance on the fresh root yield, plant height and harvest index of the cassava genotypes evaluated showed high significant differences. Table1 showed that Variety performed differently with treatments. Varieties 6 and 7yielded higher without the addition of external input,variety4 with the combination of organic and inorganic, while variety 3 ranked same with half level of NPK . Table 2 showed that control maintained best harvest index due the variety capacity where varieties 3(0.7cm) and (0.6cm)5 respectively. Other treatments did not influence harvest index much. Table3 shows that the combination of organic manure and inorganic fertilizer gave higher plant height (v1-150,a6-140andv3 137).This was followed by half level 2ookg of NPK fertilizer. Lack of additional input affected plant height negatively as seen in v1. With regards to the objectives of the study varieties 5 treatment 1 (V_5T_1) and variety 6 treatment 1(V_6T_1) shows high potential for high yield without the addition of external input, so should be selected for organic farming and poor resource farmers. Varieties 3 treatment 3, (V3T3) and variety 7 treatment$_{3\ (V7T3)}$ performed will with the combination of organic and inorganic fertilizer,

CONCLUSION:

Breeding cassava varieties which require low or no additional input to give reasonable yield is very important to meet the need of low income farmers who incidentally are the major producers of cassava and the result obtained from this work revealed that genotype 5,6 and 7 are promising genotypes which can alleviate farmers of the burden of additional input in cassava production,

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TABLE:2

EFFECT OF DIFFERECT LEVELS OF TREATMENT ON THE HARVEST INDEX OF NEWLY DEVELOPED MATERIALS

VARIEIETIES TREATMENTS	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	
CONTROL	26.3^{abc}	18.0^{abc}	23.8^{abc}	29.0^{abc}	37.0^{a}	32.7a	27.2abc	17.7abc	17.0abc	18.55abc	16.5abc
COMBO+I	19.2bc	32.0a	24.0abc	36.0a	21.1abc	22.6abc	26.05abc	17.3abc	12.5abc	10.70bc	18.0abc
HALFI	14.3abc	7.0c	36.0a	18.4abc	28.6abc	23.0abc	25.0abc	19.0abc	12.5abc	6.5c	17.5abc

KEY: v = ** NR/12/pd/036, **2 = NR/12/pd/033,v3= NR/12/pd/014,v4=NR/12/001, V5=NR/12/pd/005,V6= NR/12/pd/031 ,V7= NR/12/pd/038,V8= NR/12/pd/006,V9= NR/12/pd/004,V10=NR/12/pd/200

TABLE 2

EFFECT OF DIFFERECT LEVELS OF TREATMENTON THE HARVEST INDEX OF NEWLY DEVELOPED MATERIALS

TREATMENT	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
CONTROL	0.5b	0.5b	0.7a	0.5abc	0.6ab	0.6ab	0.5abc	0.4bcd	0.4bcd	0.4bcd
COMBOF HFF +HP	0.4abc	0.6ab	0.5abc	0.5abc	0.5abc	0.5abc	0.5abc	0.4bcd	0.4bcd	0.3cd
HALFI FERT	0.2bc	0.2bc	0.6ab	0.4bc	0.5abc	0.5 abc	0.4bc	0.4bcd	0.3c	0.3cd

KEY: v1 = NR/12/pd/036, v**2** = NR/12/pd/033,v3= NR/12/pd/014,v4=NR/12/001, V5=NR/12/pd/005,V6= NR/12/pd/031 ,V7= NR/12/pd/038,V8= NR/12/pd/006,V9= NR/12/pd/004,V10=NR/12/pd/200

TABLE 3

EFFECT OF DIFFERECT LEVELS OF TREATMENT ON THE HARVEST INDEX OF NEWLY DEVELOPED MATERIALS

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
TREATMENT										
CONTROL	0abcd	102.5abcd	103abcd	111abc	115.0abcd	140b	92abcd	97.5abcd	114abc	62.5abcd
COMBOF HFF +Hp	150a	135.0ab	137.5ab	112abc	135.0ab	140b	85abcd	126ab	85abcd	106.5abc
HALF FERT	95.0abcd	107.5abcd	75.0abcd	107.5abcd	153a	138ab	118abc	118abc	100abcd	96.5abcd

KEY: v1 = NR/12/pd/036, v **2=** NR/12/pd/033,v3= NR/12/pd/014,v4=NR/12/001, V5=NR/12/pd/005,V6= NR/12/pd/031 ,V7= NR/12/pd/038,V8= NR/12/pd/006,V9= NR/12/pd/004,V10=NR/12/pd/200

Sub-Theme C:
Animal production, Nutrition, Health, Genetic improvement and welfare and Fisheries and aquaculture production, nutrition, genetic improvement and postharvest technology

Serological estimates of grower pigs fed pineapple (A*nanas comosus*) wine sediment based diets

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ABSTRACT
A 35-day feeding trial was conducted to determine the serological estimates of grower pigs fed sun-dried pineapple wine sediment (PWS).A total of sixty-four (64) grower pigs of 3-4 months old with similar live weights averaging between 21±0.7kg were randomly assigned to four dietary treatments replicated four times in a Completely Randomized Design (CRD) experiment with 4 grower pigs per replicate. Four experimental diets were formulated such that PWSM replaced maize at 0%, 10%. 20% and 30% dietary levels coded as T_1, T_2, T_3 and T_4 respectively. Results shows that glucose, total protein, albumin and globulin values increased as dietary PWSM increased in the diets, an indication of optimum metabolism of energy and the synthesis of blood forming metabolites. It is recommended that PWS be included up to 30% replacement level for optimum biochemical stability and production efficiency.

INTRODUCTION
Animal agriculture sought to fulfill two mandates of United Nations Sustainable Development Goals notably poverty reduction(SDG 1) and optimum food supply (SDG 2). In the wake of dwindling oil prices in the world market, climate change challenges, population explosion and post COVID-19 pandemic, diversification of the economy of sub Saharan African (SSA) countries notably Nigeria through crop and animal agriculture is a step in the right direction (Nkwocha *et al.*, 2021). According to world population prospects (2019) meat consumption will continue to increase in developing countries to march with alarming projected rate of 9.7 billion in the next 30-50 years. The rising pig production globally is therefore to accommodate rising demand in animal protein intake (Nkwocha *et al.*, 2014).

Pig production is a viable and profitable enterprise despite its association with social and religious taboos (FAO, 2011).On good health perspective, pork which is the meat obtained from pig is the most concentrated and easily assimilated nitrogenous food and a good source of first class protein very stimulating to metabolism (Nkwocha and Anukam, 2012). The world trend today is towards the consumption of more white than red meat because white meat yields less cholesterol than red meat (Holness, 2005).

On the corridor of upward spiral trend in pork consumption, intensification of pig production therefore will require adequate supply of feed throughout the year. Conventional feedstuffs are very expensive and since swine competes with humans for food, looking into some unconventional feed raw materials like pineapple (Ananas comosus) wine sediment, a by-product of pineapple wine production will reduce the cost of feeding in the livestock industry and boosts economic prosperity.

Pineapple wine sediment meal (PWSM) is a viscous residue deposited at the bottom of stock-fermenting vessels over a period of time after filtering out the pure wine. The lees or sediment are made up of precipitated solids and dead yeast cells that accumulate at the bottom of the fermentation vessel in wine making (Jacobs, 2001).

The residue is extracted from mixture of raw materials such as pineapple pulp, Brewer’s yeast slurry, peptic enzymes, residual sugar, bentonite, glycerin, vitamins and mineral components, stabilizers, caramel, acetic acid, tannin and alcohol.
Serum biochemical assay on PWS will provides information about the organs and tissues in the body, as well as the animal's metabolic state subjected to this potential ingredient vis-à-vis, guaranteeing its wholesome acceptability as a feed raw material.

MATERIALS AND METHODS

Location of study:
The study was carried out at the Teaching and Research Farm of the Imo State University, Owerri which lies within the humid tropical rainforest zone of South Eastern Nigeria. The climatic data of Owerri obtained from NIMET (2015) Official Website (nimet.gov.ng/content/nimet-weather) showed that Owerri lies within latitudes 5°45'N and 7°15'N, and longitude 6°50'E and 7°25'E with an annual rainfall range of 2400-2500mm and annual temperature range of 26°C- 29°C while relative humidity is between 70-78% annually.

Experimental Animals and Design
Sixty-four (64) grower pigs of 3-4 months old with similar live weights averaging between 21±0.7kg were used for the study. The pigs were housed in pens measuring 48m^2 divided into 16 compartments with each floor measuring 4.0 x3.0 m. The 64 grower pigs used for the study were randomly divided into 4 treatment groups of sixteen pigs and fed the experimental diets as specified in Table 2. Each treatment was replicated four times in a Completely Randomized Design (CRD) experiment with 4 grower pigs per replicate.

Grower pigs were acclimatized/adapted in the study area by feeding them the control diets and supplying them water *ad libitum* for one week physiological adjustment period. Routine management practices notably deworming and the administration of antibiotics (Oxytetracycline Long Acting injection) were observed accordingly. After adaptation, pigs were weighed using small ruminant weighing scale (0-50kg) at the commencement of the experiment and weekly thereafter for a period of 35 days.

Feed preparation and feeding

The wet pineapple wine sediment (PWS) used for this experiment was obtained from a popular winery at Imo State. The product, on collection, was stored in air-tight containers to avoid oxidation and reduction reaction which if allowed, would reduce the nutritional quality of this ingredient. After collection and storage, the sediment was air-dried for seven days and then pulverized before incorporation into the experimental diets.

Four experimental diets were formulated such that pineapple wine sediment meal (PWSM) replaced maize at 0%, 10%. 20% and 30% dietary levels coded as T_1, T_2, T_3 and T_4 respectively. Other ingredients apart from PWSM in the diets were included at equal ratios. Table 1 shows the ingredient composition of the experimental diets. The experimental diets were subjected to proximate analysis using AOAC, (2000) method and resulting proximate composition is shown in Tables 2 respectively.

Table 1: Proximate composition of sun-dried Pineapple Wine Sediment Meal.

Parameters	Concentration (%)
Crude Protein	22.88
Ether extract	4.43
Nitrogen free extract	53.76
Crude fibre	7.28
Ash	11.65
Moisture content	14.19
Metabolizable Energy(kcal/kg)	2778.24 kcal/kg.

ME = Metabolizable energy calculated; ME (kcal/kg) = 37 x %CP+81 x %EE + 35.5 x %NFE (Pauzenga, 1985)

Blood sample collection

At the end of the five weeks feeding trial, two pigs were randomly selected from each replicate, and 5ml blood sample was collected through the vein at the ham section for serum biochemical analysis. The blood collected was used for the analysis of serum parameters (albumin, total protein, glucose, cholesterol, urea, etc).

Data analysis

All data obtained were statistically analyzed using the General Linear Model (GLM) procedure of SAS, (2001) for the analysis of variance, while differences in treatment means were separated using Duncan's Multiple Range Test from the same software package.

Table 2: Percentage composition of the grower pigs ration containing graded levels of PWSM.

Ingredients	Dietary treatments			
	T_1	T_2	T_3	T_4
Pineapple wine sediment meal	0.00	4.00	8.00	12.00
Maize meal	40.00	36.00	32.00	28.00
Groundnut cake	12.00	12.00	12.00	12.00

Wheat offal	20.00	20.00	20.00	20.00
Rice meal	11.00	11.00	11.00	11.00
Fish meal	3.00	3.00	3.00	3.00
Palm kernel cake	10.50	10.50	10.50	10.50
Bone meal	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25
Vit/min.premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00

* Composition per 2.5kg: Vitamin A 10000000IU, Vit.D 2000000IU, Vit E 20000IU, Vit K 2250mg, Thiamine 1750mg, Riboflavin 5000mg, Pyridoxine 2750 mg, Niacin 27500mg, Vit B12 15mg, Pantothenic acid 7500mg, Folic acid 7500mg, Biotin 50mg, Choline chloride 400gm, Antioxidant 125g, Manganese 80g, Zinc 50g, Iron 20g, Copper 5g, Iodine 1.2g Selenium 200mg, Cobalt 200mg.

RESULTS AND DISCUSSION

The proximate composition of PWS is shown in Table 1.The ingredient composition of experimental diets is on Table 2, while the serum biochemical estimates are summarized on Table 3 respectively.

The glucose values of pigs fed T_2 (10%), T_3 (20%) and T_4 (30%) are significantly the same (P<0.05) which shows positive energy level contribution of the treatment. Glucose values increased as dietary PWSM increased in the

Table 3: Serum biochemistry of grower pigs on graded level of dietary PWSM

	Dietary treatments				
Parameters	**T_1**	**T_2**	**T_3**	**T_4**	**SEM**
Urea (mg/dl)	**13.50^{b}**	**16.00^{ab}**	**20.00^{ab}**	**22.00^{a}**	**2.50**
Creatinine (mg/dl)	**1.70^{b}**	**2.00^{ab}**	**2.30^{ab}**	**2.70^{a}**	**0.31**
Glucose (mg/dl)	**32.30^{c}**	**37.40^{b}**	**38.60^{ab}**	**39.30^{a}**	**0.61**
Cholesterol (mg/dl)	**112.50^{b}**	**119.00^{b}**	**112.50^{c}**	**128.00^{a}**	**1.80**
Total protein (g/dl)	**67.90^{b}**	**74.40^{ab}**	**76.00^{ab}**	**80.50^{a}**	**2.60**
Albumin (g/dl)	**28.00^{b}**	**31.30^{ab}**	**32.60^{ab}**	**35.70^{a}**	**1.69**
Globulim (g/dl)	**39.90^{b}**	**43.10^{a}**	**43.40^{a}**	**44.80^{a}**	**0.90**

^{abc} Means along the row having different superscript differ significantly at P<0.05 level of (LSD).

diets, an indication of optimum metabolism of energy in the body.

The urea level of grower pigs fed on T_3 (20%) and T_4 (30%) are significantly the same (P<0.05) while grower pigs fed on T_1 (0%) and T_2 (10%) differed significantly (P<0.05). Creatinine values decreased with increase in the level of PWSM in the diets of grower pigs. Creatinine is a waste product of endogenous protein found in muscle and blood and is excreted in the normal urine. T_4 (30%) was the least (1.70mg/dl), however, the normal value of creatinine in grower pigs is (0.8-2.3mg/dl). T_1 recorded the highest 2.70 mg/dl which differs significantly (P<0.05) from T_3 (20%) and T_4 (30%) respectively. Comparing the normal level from T_1, it appears that T_1 (the control) is slightly higher than the normal range which is an indication of slight muscle wastage. (Udoyong *et al*., 2010).

The cholesterol values of pigs fed on T_4 (PWSM 30%) differed significantly (P<0.05%) from T_1, T_2 and T_3. T_4 recorded the least value of 112.50mg/dl followed by T_3 while T_1 recorded the highest value of 128.00mg/dl buttressing the fact that the dietary increase in PWSM based diets inversely reduces the level of cholesterol in the body of grower pigs which is an indent of good pork quality (Amarson, 2019). The serum protein, albumin and globulin concentrations increased proportionally as dietary PWSM increased in the treatment diets (P<0.05). Serum albumins and serum globulins are soluble proteins abundant in animals (Merck Manuals, 2016). Their optimal levels in the blood determine the level of immunoglobulins responsible for immune responses in the body (Coffey and Cromwell, 2001; Merck Manuals, 2016). The significant increase (P<0.05) in the concentration of the serum parameters indicates that PWSM contains significant amounts of functional protein, including immunoglobulin gamma (IgG), transferrins, haptoglobulin and several hormones and growth factors which positively influences the synthesis of blood forming metabolites.

CONCLUSION AND RECOMMENDATIONS

From all indications, PWS based diets promoted highest values in glucose, total protein, albumin and globulin parameters. In view of the above results, PWS should be included in the ration of growers as partial replacement for maize at 30% level for optimum production efficiency.

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Nutritional requirements of lactating mothers and its advantages

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ABSTRACT
Lactating women are among the most nutritionally vulnerable groups of a population due to their higher nutritional physiological requirements, which are often not met. This could induce detrimental effects of metabolic disturbances and irreversible physiological alternations on their health. This paper points out the required nutritional intakes to enhance adequate lactation which improves gestation health, prevents maternal death, child mobidity and enhance growth from birth.

Key Words: Lactation; Nutrition; Physiological Requirements and Health.

INTRODUCTION
Nutrition is a vital indicator of the complete health of a population and pillar of development (Picciano, 2018). A balanced amount of nutrients is necessary for the proper functioning of the body system. However, the nutritional requirements of everyone differ according to age, gender, physical activity levels and physiological states such as pregnancy, infancy, lactation, etc. Lactation is the process of synthesizing and secreting milk from the breasts to feed young ones. It is an integral part in the physiologic completion of the reproductive cycle of mammals. (Demissie, 2003).

Lactating women and children are among the most nutritionally vulnerable groups of a population due to their higher nutritional physiological requirements, which are often not met, could induce detrimental effects of metabolic disturbances and irreversible physiological alternations on their health (Marcos, 2017). Consequentially, low quality and quantity of milk is secreted and this has a long-term impact on the child's health (Allen, 2012). The diet consumed by the mother will not only fulfil her own nutritional needs but will also enable her to produce enough milk for her infant (Valinda 2018). Breast milk is an ideal food for infants which provides multiple nutrients, including energy, for up to a year and a major source of calories and protein in a diet for two years or more (Sanusi, 2019). Also, it offers protection against diseases. It is regarded as the most precious gift a mother can give to her infant.

Human Milk
Human milk provided by healthy, well-nourished mothers represents the best food available for infants born at term to healthy mothers (Olivia et al., 2013).Exclusive breastfeeding is recommended for the first 6 months of life, with continued breastfeeding along with appropriate complementary food up to 2 years or beyond (Olivia et a..,; 2013).

Unlike infant formula, which has a standardized composition, human-milk composition changes dynamically within a feeding, with time of day, over lactation, and between mothers and populations (Olivia et al., 2013). It is influenced by genetic and environmental factors, by infant sex and infective status, as well as by maternal lifestyle, including dietary habits. For example, colostrum, the milk produced in the first few days after birth, is reported to be higher in protein, vitamin A, vitamin $B_{12,}$ and vitamin K. Over the following 4 weeks milk composition changes gradually and is only considered “mature” from the sixth week after birth. However, subtle changes in milk composition do occur over the course of lactation (Olivia et a; 2013).

Maternal nutrition

Nutrition plays a major role in maternal and child health and it is widely recognized that optimum nutrition in early life is the foundation of long-term health (Irene and Arianna 2015). A healthy maternal dietary pattern, along with adequate maternal body composition, metabolism, and placenta nutrient supply, reduces the risks of maternal and foetal death and long-term effects in children (Irene and Arianna 2015). Maternal malnutrition in current years has turned out to be an integral theme of public challenge (Prince, 2020) as it is associated with upward push in maternal-child morbidity and mortality and known to accentuate the risk of poor pregnancy outcomes such as obstructed labour, premature birth or low-birth-weight (LBW) babies and postpartum hemorrhage (Gebre 2008). In many low-income countries, women spend a large portion of their reproductive years under nutritional stress because of chronically low dietary energy intakes, high energy expenditure related to work, and high energy and nutrient demands of pregnancy and lactation .(Aiperi et al, 2022)

In Africa and Asia, where chronic energy deficiency is more prevalent, most women are pregnant or lactating between age 35-48 of their reproductive years (Michelle , 2016). Typically, women are pregnant or lactating for 23% (Costa Rica) to 61% (Pakistan) of the time between the ages of 15 and 45 years respectively. New evidence indicates the importance of maternal nutrition for the first 2 years of child life for prevention of stunting and subsequent obesity and non-communicable diseases in adulthood. Similarly, poor maternal nutrition prior to and during pregnancy is strongly linked with increased risk of maternal anaemia, mortality, and adverse birth outcomes such as Low Birth Weight (LBW) and Preterm Birth (Shweta et al., 2019).

Determinants of Maternal Nutrition

Malnutrition manifests itself as a function of many and complex factor. It is directly linked to the inadequacy of diet and diseases under severe living factors which include crisis in *families, food insecurity, inappropriate child care* and feeding practice, unhealthy place of residence (Masresha *et al.,* 2019), etc. The following are the prevalent factors causing malnutrition associated with pregnancy, lactating mothers, and children in many African countries:

Marital Condition

Studies have shown that bad marital condition from a wife perspective was found to be a vital predictor of mothers’ nutritional status. Therefore, bad marital condition affects the support and care the mother should get from her partner and can directly affect her nutritional condition. (Abel et al, 2019).

Maternal age

Maternal age according to a study showed a statistically significant association with maternal under nutrition among mothers (Mohammed et al, 2020). Based on a recent study, it was evidenced that the age of the mother significantly influences her nutritional status (Mohammed et al, 2020).

As the age of a mother increased by one year, her risk of under nutrition decreases. In the case of young mothers, asides from inadequate development of their reproductive system and their need of nutrition for their growing body, they are often suddenly confronted by uncomplimentary nutritional conditions (Mohammed et al, 2020). Other factors include; Household food insecurity and Family size.

Nutritional requirements during lactation

The nutrient intake of lactating women is one of most important determinants of women's health, well-being and the ability for long-term successful breastfeeding. Many essential nutrients are secreted into breast milk and they represent a significant proportion of nutrient intake in the maternal diet, including docosahexaenoic acid (DHA), and most vitamins, vitamin B2, vitamin A, etc. Therefore, nutritional requirements for lactating women are higher compared to women who do not breastfeed. Table 1.0 shows the requirements in their different proportions.

TABLE 1.0

MINIMUM NUTRIENT REQUIREMENTS FOR HEALTHY WOMEN AS WELL AS PREGNANT AND LACTATING WOMEN

Nutrient	Recommended daily allowance (RDA)(healthy adults	Pregnancy (add to RDA)	Lactation (add to RDA)	Tolerable upper intake level (UL)
Intake				
Proteins	50 g	+10 g	15 g (0---6 months) +12 g (6---12 months)	ND (do not exceed tolerable upper intake levels during lactation)
Fat-soluble vitamins				
Vitamin A	700 micrograms	+70 micrograms	+600 micrograms	3000 micrograms
Vitamin D	+5 micrograms	0 micrograms	0 micrograms	50 micrograms
Vitamin E	15 mg	0 micrograms	+4 mg	1000mg
Vitamin K	90 micrograms	0 micrograms	0 micrograms	ND
Water soluble vitamins				

Biotin	30 micrograms	0 micrograms	+5 micrograms	ND
Folic acid	400 micrograms	+200 micrograms	+100 micrograms	1000 micrograms
Niacin	14 mg	+4 mg	+3 mg	35 micrograms
Pantothenic acid	5 mg	+1mg	+2 mg	ND
Riboflavin	1.1 micrograms	+.3 mg	+.5 mg	ND
Thiamine	1.1 micrograms	+.3 mg	+ .3 mg	ND
Vitamin B_{12}	1.3 micrograms	+.6 mg	+ .7 mg	25 mg
Vitamin B_6	2.4 micrograms	+.2 micrograms	+.4 mg	ND
Vitamin C	75 micrograms	+10 mg	+45 mg	2000 mg
Minerals				
Calcium	1.000 mg	0 mg	0 micrograms	2500 mg
Phosphorus	700mg	0 mg	0 mg	3500 mg
Magnesium	310mg (19-30 years) 320 (31-50 years)	+40 mg	0 mg	350 mg
Dietary Element				
Chromium	25 micrograms	+5 micrograms	+20 micrograms	ND
Copper	900 micrograms	+100 micrograms	+400 micrograms	10000 micrograms
Fluoride	3 mg	0 mg	0 mg	10 mg
Iodine	150 mg	+70 micrograms	+140 micrograms	1100 micrograms
Iron	18 mg	+ 9mg	±9 mg	45 mg
Manganese	1.8 micrograms	+.2 mg	+0.8 mg	11mg
Molybdenum	45 micrograms	+5 micrograms	+5 micrograms	2000 micrograms
Selenium	55 micrograms	+5 micrograms	+15 micrograms	400 micrograms
Zinc	8mg	+3mg	+4 mg	40mg

ND, not determined due to a lack of studies in these population studies in these population subsets; RDA, recommended dietary allowance. The intake must come from food sources to avoid potential overdoses

Source: Susana Ares Segura et al. 2015. The Importance of maternal nutrition during breastfeeding: Do breastfeeding mothers need nutritional supplements?

CONCLUSION

The general wellbeing of a woman during gestation (pregnancy) and lactation depends greatly on her nutrition and so also the wellbeing of the fetus and subsequent development of the child after being born as this prevents maternal death and child mobidity.

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MONOGASTRIC ANIMAL NUTRITION

Evaluation Of Baker's Yeast (*Saccharomyces Cerevisiae)* Supplemetnation On Growth Performance And Cost Benefit Of Feeding Weaner Rabbits (O*oryctolagus Cunniculus)*

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ABSTRACT

The study was conducted to evaluate the effect of baker's yeast (Saccharomyces cerevisiae) supplement in four experimental diets at different levels of inclusion in the diet, Thirty-six (36) weaned rabbits of mixed sex at 2:1 (2 Females: 1male) were randomly allotted to four treatment groups in a complete randomized design. Each treatment was replicated three times with three rabbits per replicate. The trial lasted for a period of 8 weeks. Data were collected on growth parameters (feed intake, weight gain and feed conversion ratio) and cost benefit rabbit supplemented with Baker's yeast at different inclusion levels. The result obtained revealed no significant (p>0.05) difference among the growth performance parameters measured except feed intake that was significant and cost benefit of the experimental animals also revealed feed cost increased with an increased level of baker's yeast supplement, from the result obtained, it can be reported that best weight gained was recorded in treatment three diet having less level of yeast inclusion and therefore could be recommended

Key words: baker's yeast, supplementation, growth, performance, cost

INTRODUCTION

The human population growth in developed countries is stabilizing while that of developing countries including Nigeria is still increasing rapidly. Thus, the search for alternative sources of protein to meet up the population challenges is imperative. Economic indices indicate that as this population trend continues, more people are to be fed. Agricultural outputs needs to be increased rather than through food importation into such countries. In order to maximize food production and meet protein requirements in Nigeria, viable options need to be explored and evaluated (Owen *et al.,* 2008). Among such alternatives is the use of livestock species that are yet to play a major role in animal production within these countries. Fast growing micro livestock such as rabbits possess a number of features that might be of advantage. The yeast is a probiotic and a possible strategy alternative because of its availability, safety and cheapness. It is a valuable and qualitative growth promoter for feeding livestock (Shareef and Al-Dabbagh, 2009)

Aim of the study

The aim of the trial is to evaluate the effect of baker's yeast on the growth performance and cost benefit of feeding the weaned rabbit supplemented with baker yeast ***(Saccharomyces cerevisiae)***

The objectives of the study are:

i. to determine the growth performance of weaned rabbits fed with different level of baker's yeast (*Saccharomyces cerevisiae)* supplement
ii. to evaluate the cost benefit of weaned rabbits fed different level of baker's yeast (*Saccharomyces cerevisiae)* supplement

MATERIALS AND METHODS

Location of experimental site:

The experiment was conducted at the Rabbitry unit of the Teaching and Research Farm, Department of Animal Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University Lapai, Niger State, Nigeria. Lapai lies between latitude 9^{o}31 and 9^{o}45, each of the equators. Savannah Vegetation Zone of Nigeria with mean rainfall ranges between 1100-1600mm and mean temperature 21^{o}C and 36.5^{o}C (6). 21^{o}C and 36.5^{o}C (Usman 2011).

Experimental animals and their management

Thirty-six (36) weaned rabbit aged 5-6 weeks were used and of both sexes (twenty-four females and twelve males), were randomly allotted to four treatment groups. Each treatment had three replicates with three rabbits per replicate (one males two females). The rabbits were housed intensively in a well-constructed hutches that were made of wire and woods with trays to collect the faeces as well as for easy cleaning of the hutches. The hutches were equipped with feeders and drinkers. The hutches were cleaned twice daily throughout the study period. lasted 8 weeks The rabbits on all the treatments were kept under close observation for proper monitoring indication of ill-health. The rabbits were dewormed against endoparasite using ivermecin, coccidiosis was treated once using sulphadimidine and multivitamin soluble powder (vitalyte) were given as an anti-stress

Source of Feed Ingredients, rabbits and Test ingredients / Experiment diets

Groundnut cake (GNC), Bone meal (BM), Limestone, premix wereobtained from Fauziya farm adjacent Gidan Matasa feed Ingredients milling Factory, Minna, while Maize and Salt were obtained from Lapai Market. Thirty-six weaned rabbits of mixed sexes were sourced from rabbitry section Niger state veterinary clinic Minna. A commercial baker's yeast (*Saccharomyces cerevisiae)* was used as the (test ingredients) dietary supplement. Four experimental diets were formulated. Diet 1 (basal diet), which was design as TRT_1 and without supplementation of *Saccharomyces cerevisiae*, serve as control diet. Diet 2, 3, and 4 were design as $TRT_{2,}$ TRT_3 and TRT_4 respectively.

Table 1: Composition of Experimental Diet

Ingredients (%)	T1	T2	T3	T4
Maize	76.00	75.80	75.60	75.40
Groundnut cake	20.00	20.00	20.00	20.00
Fish meal	1.50	1.50	1.50	1.50
Lime stone	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25

Salt	0.25	0.25	0.25	0.25
Baker's yeast (kg)	-	0.20	0.40	0.60
Total	100	100	100	100
Calculated values				
Crude protein(%)	17	17	17	17
Metabolizable energy(Kcal/kg)	**2,799.128**	**2,799.128**	**2,799.128**	**2,799.128**

Key: T_1= Treatment one (Concentrate +0kg Baker's yeast*)* T_2= Treatment Two (Concentrate + 0.20kg Baker's yeast) T_3= Treatment Three (Concentrate + 0.40kg Baker's yeast) T_4=Treatment Four (Concentrate + 0.60kg Baker's yeast) into three replicates, each comprising 3 rabbits.

Data collection

Data on growth were generated on the Initial weight = weight taken at the beginning of the experiment

Final weight gain = weight taken at the end of experiment

Total weight gain = final weight – initial weight (g)

$$\text{Daily weight gain} = \frac{\text{final weight – initial weigh}}{\text{Number of days}} \text{ (g)}$$

$$\text{Feed conversion ratio} = \frac{\text{Quantity of Feed Consumed}}{\text{Weight gain}} \text{ (g)}$$

Cost Benefit Analysis

All the feed ingredients acquired and processing activities involved were monetized and price per kg of each ingredient were determined for economic analysis. Veterinary care and miscellaneous (variable cost); this were calculated as the total amount of money spent on vaccines, drugs and other expenses divide by the number of rabbits. Average body weight (kg); this was the final body weight of rabbits before slaughtering. Price per feed; this was calculated by taking into consideration of individual ingredients to be used in compounding the diet. This was calculated by price per (kg) feed= cost per kg of diet.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) according to the procedures of Steel and Torrie (1980) and significant means were separated using Duncan Multiple Range Test (Duncan 1955).

RESULTS AND DISCUSSION

Table 2: Proximate Analysis of the experimental diets

Treatments	T_1	T_2	T_3	T_4
Parameters	0g/kg	20g/kg	40g/kg	60g/kg
Moisture	6.20	6.20	7.60	6.60
Crude protein	13.65	13.60	13.86	13.00
Crude fibre	10.50	10.22	7.24	6.00
Ether extract	7.48	6.38	6.74	7.00
Ash	7.21	8.33	7.34	7.63
Nitrogen free extract	54.96	55.27	57.22	59.77

Table 3: Growth Performance of Weaned Rabbits Fed Different Levels of Baker's Yeast as Supplement

Parameters	T_1	T_2	T_3	T_4		
Inclusion level (g)	0g/kg	20g/kg	40g/kg	60g/kg	SEM±	LSD

Initial weight	633.33	611.11	633.33	633.33	39.89	NS
Final weight	868.67	873.67	923.00	859.00	97.39	NS
Total body weight gain	235.33	262.55	289.67	225.67	69.91	NS
Total Feed intake	3450.73^{b}	4069.00^{a}	4221.00^{a}	4221.00^{a}	246.69	*
Weekly body weight gain	29.42	32.82	36.21	28.21	8.76	NS
Weekly feed intake	431.34^{a}	508.63^{ab}	527.63^{b}	527.63^{ab}	39.28	*
Feed conversion ratio	14.66	15.50	14.57	18.70	6.04	NS

a, b, c: Means with different superscripts on the same row differ significantly (P<0.05), NS=not significant, * = significant, S.E.M=Standard error of mean, LS= level of significance, T_1=treatment one (0g/kg yeast), T_2=treatment two (20g/kg yeast), T_3=treatment three (40g/kg yeast), T_4=treatment four (60g/kg yeast).

The results of the growth performance of rabbits fed different level of baker's yeast as supplement. The results no reveals that significant (P<0.05) variation were observed across the treatment groups in the value of feed intake and weekly feed intake parameters with treatment three recording the highest value of (4221.00 g) and (527 .63 g) respectively. Enhancement in feed intake may be attributed to dietary live yeast addition increases the population of total rumen bacteria and which in turn helps increase feed intake as well as feed stuff digestibility, therefore, more nutrients are available to growth operations (Habeeb *et al.*, 2017). This finding is in line with Shanmuganathan *et al.* (2004) who stated a favorable leverage of yeast on weight gain for fattening rabbits which was aided by feed intake increament. Habeeb *et al.* (2006) found that average daily gain improved by 12.6 %, when yeast added to rabbit's diet. No significance (P>0.05) differences were observed in the value of initial weight gain, final weight gained, total body weight gained and feed conversion ratio. However, the highest final weight gain(923.00g), Total body weight gain (289.67) and the best feed conversion ratio (14.57) were all recorded in treatment three rabbits fed with 40g/kg of baker's yeast in the diet. This results coincided with the observation of Belhassen *et al.* (2016) who recorded that body weight gain was not significantly affected by yeast supplementation to rabbit's diet after weaning (5-11 wk). The results of the feed conversion ratio recorded from this experiment are similar to that of Kustos *et al.* (2004); Matusevičius *et al.* (2006) who noticed non-significant difference in FCR by using a commercial probiotic in rabbit diet. However, Shanmuganathan *et al.* (2004) recorded a favorable impact of yeast on feed conversion in fattening rabbits.

Table 4: Cost benefit of rabbit fed with different dietary levels of baker yeast

Parameters	T1	T2	T3	T4	LSD	SEM
Cost of feed (₦/kg)	146.40^{d}	178.40^{c}	210.4^{b}	242.2^{a}	0.50	0.00
Cost of feed consumed/rabbit (₦)	505.19^{d}	725.91^{c}	888.09^{b}	1023.17^{a}	1.00	0.00

Feed cost /weight gain(₦ /kg)	580.68^{d}	830.87^{c}	962.18^{b}	1,191.12^{a}	0.80	0.00

a, b, c: Means with different superscripts on the same row differ significantly (P<0.05), NS=not significant, * = significant, S.E.M=Standard error of mean, LS= level of significance, T_1=treatment one (0g/kg yeast), T_2=treatment two (20g/kg yeast), T_3=treatment three (40g/kg yeast), T_4=treatment four (60g/kg yeast).

The result for the cost benefit of rabbits fed baker's yeast supplement revealed the values for cost of feed, cost of feed consume per rabbit and feed cost per weight gained differs significantly (P<0.05) across the dietary treatment level. Cost of feed increased with an increased level of baker's yeast supplement, highest cost of feed produced (₦ 242.2) was obtained in Treatment four while the least cost of feed produced was obtained in treatment one (₦ 146.40). Cost of feed consume per rabbit is costlier (₦ 1,023.17) in treatment four while least expensive (₦505.19) in treatment one. Best feed cost /kg weight gained (580.68 ₦/kg) was recorded in treatment one while the poorest (₦ 1,191.12kg) was obtained in treatment two. The cost of the experimental diet and the feed cost per weight gain were higher in treatment four because treatment four contained high inclusion level of the yeast. However, the best weight gained was recorded in treatment three diet having less level of yeast inclusion when compare to treatment four. This finding strengthen the evaluation of Ezema and Eze (2015) they recorded high cost of experimental diet/kg in group C because group C had the highest probiotic inclusion of 0.16 g/kg of diet but did not gain as much weight as group B (0.12 g/kg of diet). This might be explained by the fact that probiotics are not dose dependent but are threshold dependent (Ortwin,2005).

CONCLUSION:

From the results obtained from this study it can be deduced that rabbits diet supplemented 40g/kg performed better in the parameters considered. Thus, rabbits diet can be supplemented with baker's yeast without having any adverse effect on the growth performance and cost benefit of rabbits diets.

RECOMMENDATION:

Based on the above results, 40g probiotic baker's yeast /kg of diet was thus recommended for maximum weight gain and optimum economic benefit in rabbit production

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Influence Of Varied Dietary Inclusion Of Cassava Root Meal On Performance Characteristics Of Broiler Chickens In The Starter Phase

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ABSTRACT

A 21 days feed trial on processed cassava root meals using oven-dry and sun-dry techniques were substituted at varying inclusion levels in broiler starter chicken diets. Data were collected on the proximate composition of CRMs and performance characteristics of the broiler starter chickens. The results of the proximate composition revealed that moisture, dry matter, crude protein, crude fibre, ash, ether extract and Nitrogen free extract were 8.79, 27.47, 4.25, 3.68, 3.48, 0.60 and 47.73% respectively for oven-dry CRM, and 7.39, 29.10, 3.85, 4.08, 2.63, 0.44 and 48.51% respectively for sun-dry CRM. The results showed that the final weight and weight gain of birds on Treatment 4 had superior values 1242.70g and 1242.25g respectively compared to birds on other treatments. The feed intakes of the birds ranged from 1695.81 – 1785.03g. Also, birds on T4 showed better FCR compared to the other treatments. It is recommended that processed CRM could be fed to broiler starter chickens up to 50%CRM inclusion either as sun-dry or oven-dry for improved growth performance.

Keywords: Broiler starter chickens, cassava root meal (CRM), performance characteristics and proximate composition

INTRODUCTION

The effects of covid-19 and climate change recently have negative impact on agricultural production globally. There has been a closure of several farms within Nigeria and some low-income countries due to a hike in the prices of feed resources and its unavailability for use in animal production had been challenging. The usage of non-conventional feed resources hascontinued to be widely appreciated in the livestock industry due to their availability and cheaper compared to conventional feed resources (Okpara *et al.*, 2022).
Cassava (*Manihot esculenta*) is a plant that has been widely used both for humans and animals. Its leaves are an excellent meal for ruminants. It is among the most cultivated plant globally. It grows all year round and can thrive in most soils in Nigeria. There are several varieties which are most predominant in the tropics. Its root tuber can be processed (sun-drying, boiling, oven-drying) into various products consumed by man, and animals and its by-product for industries.

This research was designed to evaluate the effects of these processing techniques on cassava root meal as partial or whole substitution in broiler starter chickens on their performance characteristics.

MATERIAL AND METHODS.

Experimental Location and Site

The experiment was carried out in the teaching and research poultry unit at Dennis Osadebay University, Asaba, Delta State. The poultry unit had a deep litter system which is partitioned into pens with netting materials. Each pen had a space of 1x2x2.5.

Processing of test ingredient and experimental diets.

The cassava variety used was UMUCASS 36 (vitamin A) and was harvested 9 months after planting. The tubers were peeled, washed with water to remove impurities and sliced before being sun-dried for (5days) and oven-dried at 60^{o} C for 6hrs respectively. The dried samples were ground into meals and kept in sacks before usage. These meal samples were supplemented as partial and whole into six diets as a substitute for maize in the birds' diets. T1 serves as the control, T2 had 25% each of oven-dry and sun-dry CRM, T3 had 25% maize and 25% oven-dry CRM, T4 had 25% maize and 25% sun-dry CRM while T5 had only 50% oven-dry CRM and T6 also had only 50% sun-dry CRM respectively.

Table 1: Percentage composition of broiler starter chicken diets

Feedstuff	T1	T2	T3	T4	T5	T6
Maize	50.00	---	25.00	25.00	---	---
Oven-dried cassava	---	25.00	25.00	---	50.00	---
Sun-dried cassava	---	25.00	---	25.00	---	50.00
Soyabean meal	20.00	20.00	20.00	20.00	20.00	20.00
Groundnut cake	14.00	14.00	14.00	14.00	14.00	14.00
Wheat bran	8.50	8.50	8.50	8.50	8.50	8.50
Palm Oil	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00	1.00
Methionine	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values						
Crude protein%	23.08	22.44	22.84	22.96	23.06	22.92
ME(Kcal/kg)	2872.11	2852.27	2882.50	2896.70	2876.44	2882.56

Experimental animals and design.

A total of 108 Arbor acre day-old chicks were used. The birds were randomly distributed in a completely randomized design into the various treatments. Each treatment was replicated thrice with 6 birds per replicate respectively. Feed and water were administered *adlibitum* for 3 weeks. One-way ANOVA was used to analyze and their means were separated using Duncan Multiple Range Test.

Proximate composition

Proximate compositions of the samples were carried out according to the AOAC 2015 procedures. Hydrogen cyanide (HCN) content was determined using Chisenga *et al.*, (2020) procedures

Data collection

Performance characteristics

Live body weight (BW) was registered at the beginning and termination of the experimental period, whereas feed intake and weight of birds were determined once a week. The weight gain of birds was recorded by subtracting the initial weight from the final weight, while the feed conversion ratio was calculated as the feed intake divided by weight gain.

Statistical analysis

All data collected were analyzed using SPSS version 23

RESULTS AND DISCUSSIONS

Table 2: Proximate composition of cassava root tuber (Vitamin A variety)

Parameters	Oven-dry	Sun-dry
Moisture (%)	8.79	7.39
Dry matter (%)	27.47	29.10
Crude protein (%)	4.25	3.85
Crude fibre (%)	3.68	4.08
Ash (%)	3.48	2.63
Ether extract (%)	0.60	0.44
Nitrogen free extract (%)	47.73	48.51
HCN (mg/100g)	3.15	2.84
Energy (kcal/kg)	2,942	2,958

The results of the proximate composition revealed that moisture, dry matter, crude protein, crude fibre, ash, ether extract and Nitrogen free extract were 8.79, 27.47, 4.25, 3.68, 3.48, 0.60 and 47.73% respectively for oven-dry CRM, and 7.39, 29.10, 3.85, 4.08, 2.63, 0.44 and 48.51% respectively for sun-dry CRM These results were inconsistence with an earlier report by Okpara et al. (2022) that also documented similar values on processed cassava on broiler chickens performance. The CP, CF and NFE results were at variance with reports of Yadav et al.(2019); Chisenga et al. (2020). Moreover, the reports of some authors on CP, CF, NFE showed discrepancies with the present results which can be aligned to the age of harvest, processing methods, cassava variety and some ecological factors (Bhuiyan and Iji 2015).

Table 3: Performance characteristics of birds fed experimental diets

Parameters	T1	T2	T3	T4	T5	T6	SEM	p-value
Initial weight/bird (g)	0.45	0.45	0.45±0.00	0.45	0.45	0.45	0.00	0.00
Final weight / bird (g)	1206.14^{ab}	1145.52^{d}	1069.42^{c}	1242.70^{a}	1051.34^{d}	1102.62^{b}	15.32	0.03
Weight gain/ bird (g)	1205.69^{ab}	1145.07^{d}	1168.97^{c}	1242.25^{a}	1050.89^{d}	1182.17^{b}	14.55	0.01
Feed intake/ bird (g)	1785.03	1712.56	1735.8l^{b}	1745.03	1695.8l^{a}	1721.28	12.06	0.04
Feed conversion ratio	1.48^{b}	1.50^{b}	1.48^{b}	1.40^{c}	1.61^{a}	1.46^{b}	0.55	0.02

a-b-c: Means within the row with different superscripts are different at $p< 0.05$. SEM: Standard Error of the Mean

The result on performance characteristics of birds showed significant ($p<0.05$) influence of the diets (Table 3). The final weight and weight gain of birds on T4 had superior values 1242.70g and 1242.25g respectively compared to birds on T1 whose values 1206.14g and 1205.69g was better than T6 < T3< T2 respectively. The feed intakes of the birds range from 1695.81 – 1785.03g, where T5 and T1 recorded the least and highest values respectively. It was observed that T4 birds had better FCR against the birds on other treatments. These results are similar with Bhuiyan and Iji (2015) but differ from Okpara et al., (2022), who reported a reduced feed intake on birds fed oven-dried CRM. Earlier reports have documented that up to 50%CRM had greater weight gain in birds (Etalem, 2013).This recommendation was consistent with this study's result.

CONCLUSION

The birds on T4 showed superior values in the final weight, and weight gain and had a better feed conversion ratio. It was also observed that broiler starter chickens could be fed processed CRM up to 50% inclusion for improved growth performance..

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Animal production, nutrition, health, genetic improvement and welfare

Assessment of species effects on physicochemical properties of ruminant animal's milk

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ABSTRACT

The composition of milk will determine its ability to meet with the requirement of an individual. The experiment was carried out at the Fulani settlement located behind Kabba College of Agriculture/ ABU. Twelve lactating cow, ewe and doe were used in a complete randomized design experiment. The animals were hand-milked and samples of milk were bulked separately and taken to the laboratory for analysis. The physical composition observed were; colour, density, pH and conductivity, while the chemical composition were total solid, protein, fat, ash and lactose using standard procedures. The colour of cow milk appeared yellow, while those of sheep and goat milk appeared white. The density of milk for cow, sheep and goats are 1.04mg/dl, 1.02mg/dl and 1.04mg/dl respectively. The pH of milk is 6.70 for cow and 6.62 for sheep and goat. Conductivity range of the milk samples was 6.14 Ms/cm for cow, 10.55 Ms/cm for sheep and 9.63Ms/cm for goat. The total solid was 14.25%, 20.70% and 15.32% for cow, sheep and goat respectively. The protein content was 4.32% in cow milk, 6.63% in goat milk and 4.63% in sheep milk. The fat content in sheep was (7.65%), cow (4.95%) and goat (5.30%). The lactose content of the milk varied between 4.47% - 5.29%. It was concluded that there were variations amidst the milk of ruminant animals considered in this study. Sheep and goat milk use can be recommended to farmers that are interested in butter production.

Key words: Assessment, Species, physicochemical ruminant and milk

INTRODUCTION

Milk is an important food for mankind and young ones of all mammals as a liquid food. Milk contains water, fat, protein, lactose, vitamins and minerals (Park, 2009). Unraveling the composition of milk and its constituents has been a challenging problem for scientists due to its complex nature. These constituents are present in three phases viz; true solution colloidal dispersion and fat-in-oil type emulsion. Knowledge of milk composition leads to understanding of physico-chemical nature of this complex biomolecule, it will also add to the knowledge needed for the preparation and manufacture of milk and its products (Haile *et al.*, 2018).

The milk composition not only reflects the dairy quality and health status of dairy animals but also affects the nutritional value of milk and dairy products (Auldist *et al*., 2007).Milk composition determines the nutritional value as well as its quality. The composition of milk will determine its ability to meet with the requirement of an individual at any given point in time. Each species of ruminant has peculiar composition which may lead to allergic reactions when consumed.

Therefore, it is necessary to investigate differences in milk composition of ruminants as occasioned by species.

MATERIALS AND METHODS

Experimental site

The experimental site was at the Fulani settlement located behind the Division of Agricultural Colleges, Ahmadu Bello University Kabba Campus, Kogi State, Nigeria, which is located within the Guinea Savanna Agro-ecological zone of Nigeria. The area experiences a tropical climate with marked wet and dry seasons, high temperature and high humidity. The rainy season spans over seven month from mid-march or early April to October. The mean annual rainfall is 750mm per annum. The dry season spans from November to early March. The average mean annual temperature of the area ranges between 32°C and 35°C.

Source of experimental materials

Milk that was used for the experiment was sourced from the Fulani settlement located behind the Division of Agricultural Colleges, Ahmadu Bello University Kabba Campus, Kogi State
Animal management and feeding
Twelve lactating animals were sourced within the Fulani settlement raised under the extensive management systems. Routine grazing was carried out twice daily (morning and evening). They were fed on natural pasture.
Experimental Design and Procedure
Milk samples were collected from the cows, goats and sheep in a completely randomized design. Twelve lactating does, ewes and cow free from disease and other infections were selected randomly to eliminate bias in the experiment. The animals were hand-milked before morning grazing. Representative samples of milk obtained from the does (West African Dwarf), ewe (The Bororo) and cow (white Fulani) respectively were bulked separately and collected into clean, white plastic containers. The samples were taken in a cold ice packed container to the laboratory for analysis.

Samples analysis.

The density of the milk was calculated by dividing the weight of the milk sample by the volume (Selvaggi *et al.*, 2014). The pH value of milk was determined by using a pH meter as described by Li *et al.* (2019). The conductivity was determined by a calibrated conductometer (AOAC, 2000). Standard procedures adopted by AOAC (2000) were followed in the determination of the percentages of total solids (TS), fat (Gerber's method) and protein (Kjeldahl's method). The lactose percentage was calculated as TS – (protein + fat + ash).

Statistical analysis

All data obtained were statistically analyzed using the Analysis of Variance (ANOVA) procedure of SAS (2002) while the significant differences in means were separated using pair wise-difference.

RESULTS AND DISCUSSION

Physical composition of milk from different ruminant's species

The results of the physical composition of milk from different ruminant species during the study period are shown in Table 1.The colour of cow milk appeared yellow, while those of sheep and goat milk appeared white. This agreed with the findings of Balthazar *et al.* (2017) and Saini and Gill, 1991, they reported that goat and sheep milk is white in colour compared with cow milk, which is yellowish because of the presence of carotene. In this study the density of milk for cow, sheep and goats are1.04mg/dl, 1.02mg/dl and 1.04mg/dl respectively. This agreed with the findings of Park *et al*. (2007) they reported the range value of 029–1.039mg/dl, 1.0347–1.0384mg/dl and 1.0231–1.0398mg/dl for goat, sheep and cow respectively. The variation may be as a result of differences in volume and weight of individual milk.

The pH of milk is 6.70 for cow and 6.62 for sheep and goat. The slight acidity of milk is due to the presence of lactic acid, citric acid and phosphoric acid (Balthazar *et al.*, 2017). However, their values fell within the range value of 6. 65 – 6.71, 6.61 – 6.51 and 6.62 – 6.71 for cow, goat and sheep respectively as reported by Park *et al*. (2007). The conductivity range of the milk samples was (6.14 Ms/cm) for cow, (10.55 Ms/cm) for sheep and (9.63Ms/cm) for goat. The variation in conductivity may be due to the different levels of the electrolytes present in the milk samples.(Rehman and Salaria, 2005).

Table 1: Physical composition of milk from different ruminant's species

Composition	Species		
	Cow	Sheep	Goats
Colour	Yellow	white	White
Density (mg/dl)	1.04	1.02	1.04
pH	6.70	6.62	6.62
Conductivity(Ms/cm)	6.14	10.55	9.63

Chemical composition of milks from breeds of ruminant animals

The results for the chemical composition of milks from different species of ruminant animals are shown in Table 2.

The total solid composition of milk was 14.25%, 20.70% and 15.32% for cow, sheep and goat respectively. The significant effect of species on total solid in the present findings is in line with the reports of Imran *et al.* (2017); they reported that sheep milk contains higher total solids and major nutrient contents than goat and cow milk. This may be as a result of higher proportion of nutrient constituent in sheep milk compared to goat and cow milk. According to the present result, the protein content was 4.32% in cow milk, 6.63% in goat milk and 4.63% in sheep milk. The amount of protein content in sheep milk was significantly ($p<0.05$) higher compared to goat and cow milks. This may be as a result of higher essential and non-essential amino acids as well as more whey protein fractions in sheep milk compared to the rest species (Belloni *et al.*, 1999).

The amount of fat content in milk was significantly ($p<0.05$) higher in sheep (7.65g) compared to cow (4.95g) which is similar ($p > 0.05$) to goat (5.30g). This observation is similar to those reported by Enb *et al.* (2009). This may be as a result of higher saturated, mono -unsaturated and poly –unsaturated fatty acids in sheep milk compared to cow and goat milk (Renner, 1982). The ash content of milk was significantly ($p<0.05$) higher in sheep (0.83g), although similar ($p>0.05$) to the milk content of goat (0.70g) while cow had the least ash content (0.51g).This is similar to the report of Saini and Gill (1991). This may be as a result of higher concentration of both water-soluble and fat- soluble vitamins and minerals being more in sheep and goat milk compared to cow's milk (Alichanidis and Polychronia, 1996). There was a non-significant ($p > 0.05$) difference between the percentage composition of lactose in cow, sheep and goat milk; however, their mean composition was 4.47%, 5.29% and 4.69% respectively. The values obtained in this present study is within the range of 4.10-5.24% in cow milk, 3.89-4.73% in goat and 4.42-5.31% in sheep milk reported by Enb *et al*.(2009).

Table 2: Chemical composition of milk from different ruminant's species

Species

Composition (g)	Cow	Sheep	Goat	SEM
Total solid	14.25[b]	20.70[a]	15.32[b]	0.02
Total protein	4.32[b]	6.63[a]	4.63[b]	0.03
Fat	4.95[b]	7.95[a]	5.30[b]	0.03
Ash	0.51[b]	0.83[a]	0.70[a]	0.04
Lactose	4.47	5.29	4.69	0.04

[ab]: means with different superscript in the same row are significantly ($p<0.05$) different

CONCLUSION AND RECOMMENDATION

The physical and chemical composition of various ruminant animals (cow, sheep and goat) varied amidst species and they can all serve as nutritional source of milk.

Goat, sheep and cow milk can be taken, as they will adequately serve as nutritional source of protein for human consumption, however, sheep milk seems the richest

Sheep milk is recommended for farmers interested in butter production because they contain the highest fat percentage.

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Haematological And Serum Biochemical Parameters Of Finisher Broilers Fed *Vernonia Amygdalina* And *Ocimum Gratissimum* Meals

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ABSTRACT

The study was conducted at the Research Unit of Delta State University, Asaba Campus to evaluate the haematological and serum biochemical parameters of broiler chickens fed Vernonia amygdalina (bitter leaf) and Ocimum gratissimum (scent leaf) meals. Two hundred (200) one-day-old broiler chicks were randomly assigned to five experimental diets consisting of 0% bitter leaf (BL) and 0% scent leaf (SL), 0% BL and 0%SL with antibiotic, 75% BL and 25% SL, 50% BL and 50% SL, and 25% BL and 75% SL, in a Completely Randomized Design. Results obtained showed that crude protein intake was similar among the treatment groups. The white blood cell (WBC), red blood cell (RBC), haemoglobin (Hb), mean cell haemoglobin concentration (MCHC), glucose, albumin, globulin and total protein were similar among the treatment groups. Cholesterol was significantly ($P<0.05$) highest in 25% BL and 75% SL, and lowest in 0%BL and 0%SL, in the birds fed the control diet. Since 2 – 200 mg/dl daily intake of cholesterol is recommended, it is concluded that bitter leaf and scent leaf meal can be added to the broiler diet, even at a combined level of 25% BL and 75% SL, without adverse effects on the haematological and biochemical status of broiler chickens.

Keywords: Haematology, serum biochemistry, bitter leaf, scent leaf.

INTRODUCTION

Poultry production is a necessity in the supply of animal protein, especially to developing countries in the globe, which have been disadvantaged over the centuries. Various feed additives are used in poultry production to maximize profit, performance, carcass quality, health status, and to mitigate the attendant problems of antibiotic usage. Consequently, phytochemicals, which are plants' secondary metabolites, are now included in poultry diets. This is due to their inherent antioxidant and anti-microbial activities (Ali et al, 2021). *Ocimum gratissimum* (scent leaf) and *Vernonia amygdalina* (bitter leaf) are some of the plants of interest in the quest for a panacea to the above-mentioned problems.

Consequently, nutrition is being more widely used as a practical solution for maintaining animal health. Feed components and nutrients influence health in many different ways. By manipulating or selecting them, feed quality may be maintained and the risk of mycotoxin contamination may be reduced.

Haematology is the specific study, with the responsibility of diagnosing and managing of a plethora of benign and malignant diseases of red and white blood cells, platelets, and coagulation system in living organisms (Newman, 2022). Phytochemical investigation of bitter leaf and scent leaf yielded quite different compounds such as alkaloids, tannins, flavonoids and steroids. Ugoze, *et al*. 2020, emphasized the usefulness of these phytonutrients in reducing diseases and death. This study is designed to evaluate the haematological and serum biochemical parameters of broiler chickens fed bitter leaf and scent leaf meals at varying proportions.

MATERIALS AND METHODS

The experiment was carried out at the Training and Poultry Research Unit of Delta State University, Asaba Campus. Bitter leaf (BL) and scent leaf (SL) which were procured from Asaba and the neighbourhood were air-dried separately and milled and samples were sent to the Animal Science Laboratory of Delta State University Asaba Campus for analysis of proximate composition and phytochemical substances. Five dietary treatments were formulated to contain approximately 3000 kcal/ME and 20% crude protein. The first group is the control which had 0% BL and 0% SL, the second group had 0% BL and 0%SL, with antibiotic, the third group had 75% BL and 25% SL, the fourth group had 50%BL and 50%SL, and the fifth group had 25%BL and 75% SL. The compositions of the experimental diets are presented in Table 1.

Two hundred (200) 28-days old Marshal broiler chicks were procured for this experiment. The chicks were randomly allotted to five treatment groups of 40 chicks, with each treatment group further subdivided into four replicate sub-groups of 10 chicks in a completely randomized design. Each treatment group was assigned one of the dietary treatments. Feed and clean drinking water were provided *ad libitum.*

At the end of the nine weeks of age, one bird from each of the replicates was selected at random for bleeding, through the vein. Blood samples were then analysed for packed cell volume (PCV), Haemoglobin (Hb), white blood cells (WBC) count, red blood cells (RBC) count, mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), serum total protein, albumin, globulin, glucose and cholesterol.

RESULTS AND DISCUSSION

The proximate composition and phytochemical constituents of bitter leaf (BL) and scent leaf (SL) in Table 1, showed BL to be slightly higher than SL in dry matter, Ash, Alkaloid, Tannin, Flavonoid, and Steroid. On the other hand, SL was slightly higher than BL in crude protein, ether extract and Saponins.

Table 1: Proximate Composition and Phytochemical Constituents of Bitter Leaf (BL) and Scent Leaf (SL)

Parameters	BL	SL
Dry matter (%)	91.87	90.03
Crude Protein (%)	13.52	15.52
Crude Fibre (%)	12.22	10.39
Ether Extract (%)	8.85	10.55
Ash (%)	8.18	6.73
Nitrogen free extract (%)	49.10	46.84
Phytochemicals		
Alkaloid (%)	1.34	1.18
Tannin (%)	6.00	3.60
Flavonoid (%)	2.08	1.96
Steroid (mg/dl)	0.148	0.096
Saponins (+)	++	+++

Table 2 Compositions of Experimental Diets

Inclusion levels (%)	0BL 0SL	*0BL *0SL	75BL 25SL	50BL 50SL	25BL 75SL
	Treatment				
Ingredients	**1 (control)**	***2**	**3**	**4**	**5**
Dry matter	90.20	90.34	90.55	90.78	90.58
Crude protein	20.05	20.05	20.00	20.85	20.85
Ether extract	6.30	6.80	6.45	7.11	6.85
Crude fibre	4.47	4.29	4.52	4.62	4.67
Ash	5.45	5.48	5.90	5.80	5.35
Nitrogen free extract	53.61	53.72	51.68	52.20	52.68

**** Antibiotic: (Tylo-dox extra wsp: Tylosin Tartrate 20g, Doxycycline Hyclate 15g)***

BL: Bitter leaf SL: Scent leaf

Table 3 shows the results of the haematological and serological indices of the broiler chickens. The haematological parameters of broiler chickens fed varying levels of bitter leaf and scent leaf meals indicated that PCV values (%) of 37.50 and 37.25, fell within the range of 27.50-37.50% cited by Onwumelu (2009) for broilers. Generally, dietary treatments had no significant (P>0.05) effect on the haematological indices measured except MCV and MCH. The similarity in the Hb levels means the oxygen transportation within the bird's physiological system was not affected by the diets. MCH and MCV of treatment 2 were significantly (P<0.05) higher than treatments 1 and 4, but similar (P>0.05) to treatments 3 and 5.

Table 3 Haematological and Serological Indices of Broiler Chickens Fed Diets Containing Graded Levels of Bitter Leaf and Scent Leaf Meals.

Inclusion levels (%)	0BL 0SL	*0BL *0SL	75BL 25SL	50BL 50SL	25BL 75SL	
	Treatments					
Ingredients	**1 (Control)**	***2**	**3**	**4**	**5**	**SEM**

WBC ($\times 10^{10}$/L)	4.16^{a}	4.72^{a}	3.39^{a}	3.52^{a}	4.32^{a}	0.21
RBC ($\times 10^{10}$ /L)	27.50^{b}	21.63^{b}	24.50^{b}	27.00^{b}	28.00^{b}	2.45
Hb (g/dl)	13.78^{a}	13.85^{a}	12.43^{a}	12.23^{a}	13.53^{a}	0.28
PCV (%)	41.75^{a}	42.00^{a}	37.50^{a}	37.25^{a}	41.50^{a}	0.83
MCHC (g/dl)	32.97^{a}	32.95^{a}	33.12^{a}	32.76^{a}	32.63^{a}	0.13
MCH (pg)	29.54^{c}	64.41^{a}	52.99^{ab}	46.54^{b}	51.91^{ab}	3.37
MCV (fg)	89.47^{c}	195.36^{a}	160.67^{ab}	141.97^{b}	153.48^{ab}	10.22
Glucose (mg/dl)	178.94^{a}	164.38^{a}	167.94^{a}	166.83^{a}	160.75^{a}	8.45
Albumins (g/dl)	7.33^{a}	8.04^{a}	7.62^{a}	7.19^{a}	7.93^{a}	0.14
Globulins (g/dl)	11.87^{a}	12.99^{a}	12.33^{a}	11.63^{a}	12.83^{a}	0.23
Cholesterol (mg/dl)	94.81^{c}	99.16^{c}	104.00^{bc}	120.34^{ab}	132.53^{a}	3.89
Protein (g/dl)	19.20^{a}	21.05^{a}	$19,95^{a}$	18.83^{a}	20.63^{a}	0.37

a, b, c, Means with different superscripts in the same row are significantly different (P > 0.05)
****Antibiotic: (Tylo-dox extra wsp: Tylosin Tartrate 20g, Doxycycline Hyclate15g).***
SEM = Standard error of the means
BL: Bitter leaf **SL: Scent leaf**

The glucose, total protein, albumin and globulin of birds in all treatment groups were similar (P>0.05). This is an indication that the contents of phytochemicals in bitter leaf and scent leaf meals in the diets did not precipitate inadequacy of nutrients which could create an anaemic condition. Cholesterol levels were significantly (P<0.05) higher in birds fed diets containing 50%BL and 50%SL; and 25%BL and 75%SL. This cannot be explained in this study, as it is contrary to reports on the cholesterol-lowering effect of phytochemicals as reported by Tchouan *et al*, (2020), whereby a decrease in serum LDL- cholesterol content, and an increase in HDL-cholesterol, with the addition of enzymes in cassava fibre-based broiler diets. More so, Adeloye *et al* (2021), observed that dough meals from unripe plantain, water yam and bitter leaf, have the potential to be used as functional foods to alleviate postprandial hyperglycemia. This could be an indication of hypoglycemic effect of bitter leaf on broilers.

CONCLUSION

It can be concluded from this study that both bitter leaf and scent leaf meals can be used at various levels of combination, without adverse effects on the haematological and serum biochemical parameters of broiler chickens.

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Harnessing the nutritional potentials of cassava leaf meal in pig production: a review

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ABSTRACT

Given the hike in price of some feed stuffs like cereals there is need to focus attention on alternative feed stuff which could either directly substitute conventional feed stuffs or could be included at certain levels to attain a comparable production quality without deleterious effect on the animal health, reduce the cost of production and readily available. This paper reviewed research efforts on the potentials of cassava leaf meal in pig feeding. This review shows that cassava leaf meal is readily accepted as a component of livestock feed. Cassava leaf meal is a potential source of protein supplementation for livestock. There is no competition between man and pigs for cassava leaf meal, it is readily available and cheap. Cassava leaf meal have been found to improve performance of carcass quality, growth performance; and blood serum and biochemistry in pigs when fed at different levels

INTRODUCTION

The major aim of every farm enterprise is to maximize profit. Majority of the cost in livestock productions is incurred from feed stuffs and feeding which can take up to about 70-80% of the total cost of production (Tewe *et al*., 2002).

Cassava foliage is a very good feed stuff that will help to conquer this high cost of feed in the livestock industry (Ukachukwu, 2008). Recently, emphasis has been placed on the increase utilization of cassava foliage. This opens up the possibility of including foliage and tender stems of cassava which is rich in protein in diets containing increased amount of cassava roots (Garbati *et al.*, 2001), since this material has been successfully used in pig feeding (Trompiz *et al*., 2000). Cassava leaf yields as much as 4 tones dry matter per hectare and may be produced as a by-product at root harvest (Preston 2002).

Improved productivity of pigs using Cassava foliage meal will reduce the pressure on other sources of dietary nutrients. This will invariably have a positive impact on the economy because the huge amount of the money spent annually by government in importing other sources of animal protein will be channeled to other uses.

POTENTIALS OF CASSAVA LEAF ON PERFORMANCE OF PIGLETS

Growth: Based on research carried out by Tram, Nguyen & Preston, Thomas. (2004), they observed that as the proportion of fresh cassava leaf was increased in the ration of growing/finishing pigs, growth performance was lowered. This adverse effect was suspected to be due to high levels s of hydrocyanide acid present in the fresh leaves, which affected the palatability. In another experiment to use cassava leaf meal as a substitute for other protein supplement in swine diets was not encouraging Ravindran (1990), in his work substituted 10, 20 and 30 percent leaf meal of cassava in a maize/soyabean meal based diet for pigs that are growing and discovered that the mean daily gains and feed efficiency reduced linearly with increasing levels of leaf meal. In a diet of pigs containing 10% cassava leave meal, performance was improved by addition of methionine and energy supplement. Based on research carried out by Siaka (2017), reduced gains and poorer feed intake was reported when leaf meal of cassava was added at above 30% in pigs.

Carcass: In an experiment carried out by Jiménez *et al*., (2005), they finalized that swine fed *ad libitum* with diets compounded to contain 40 percent of cassava root meal and 20 percent from mixture of cassava foliage and leaves of trichanthera had similar weight performance and carcass qualities in comparism with those fed a conventional diet. Jimenez *et al*., (2005) who fed cassava root and mixed foliage meal of cassava and trichantera leaves did not observe any significant difference in all carcass parameters analyzed. This may be an indication that the pigs in all the treatments optimally utilized the nutrients contained in the diets.

The abdominal fat value of pigs shows that as the level of Cassava foilage meal increased in the diet of pigs, the abdominal fat reduced. This might suggest that higher level of CFM led to reduction in energy density of feed, hence reduced fat deposit in the animal. It could also be due to higher crude fiber content of the foliage, which may have reduced the digestible energy content of the diet.

Haematology: Haematological profile in any farm animal is a very important indicator of health and disease condition in an animal and cannot be done without in the diagnosis, prognosis or treatment of a lot diseases (Mbanasor *et al*., 2003). Evaluation of the haematological indices shows the animal's physiological responsiveness to its external and internal surrounding haematological indices avails the opportunity to do a clinical study of many metabolites, as well as other constituents in the animal's body. A study carried out by Iyayi (2001), feeding swine with cassava leaf supplement significantly improved total protein of serum and reduced serum glutamic oxaloacetic transaminase and serum glutamic pyruvic transaminase. The value of WBC and blood coagulation time increased with increasing level of leaf meal of cassava which implies that the leaf has substance that interferes with clotting.

Nutrient Composition of Cassava Leaves: Cassava leaves contain about 21% crude protein, even though values ranging from 16.7-39.9% have been reported. This wide variation can be attributed to cultivars variations, maturity stage, procedure of sampling, fertility of the soil and climate (Hue *et al*, 2012).

Optimization of cultural activities such as fertilizer application may give another means of raising the protein value of cassava leaves. Even though cassava leaves are rich in protein, some factors such as high level of crude fire may reduce its nutritive value for monogastric animals. Maturity Stage is an important factor contributing to the variation in fibre content, but cultivar effects and environmental factors are also responsible. Cassava leaves are very nice sources of minerals. They are mainly rich in Fe,Ca, Mn, Mg, and Zn.

Cassava leaves also are rich in vitamin A and ascorbic acid, and contain reasonable amounts of riboflavin. But considerable losses of vitamins, particularly of ascorbic acid, occur during processing.

Amino Acid Composition: The protein contained in Cassava leaf is low in methionine, possibly marginal in tryptophan, but high in lysine (Chhay Ty and Preston T R 2005). Some reports have been made about differences in the amino acid profile of leaves and may be attributed to variation in procedures of sampling, stage of leaf maturity, ecological conditions and analytical methods. During leaf maturation, the obvious pattern was for the amino acid level to decrease. Among the essential amino acids, histidine and lysine appeared to decrease the greatest.

Table 1: Amino Acid Composition of Cassava Roots and Leaves (g/16g n).

Amino acid	**Roots**	**Leaves**
Threonine	2.08	3.52
Valine	2.78	5.30
Methionine	0.70	1.29
Isoleucine	2.08	4.06
Leucine	3.80	7.43
Phenylalanine	2.80	4.81
Lysine	0.35	4.81
Total	59.11	84.90

Source:Ravindran *et al.* (1982)

Table 2 : Chemical composition of cassava leaf/foliage meal

	(Root)	**(Root)**	**Leaves**	**leaves**
Crude protein (%)	3.5	2.9	34.1	20.2
Ether extract (%)	0.8	1.4	6.3	6.2
Crude fibre (%)	4.2	5.0	10.7	29.0
Ash (%)	4.1	2.3	6.2	7.8
NFE (%)	87.4	88.4	42.7	36.8

Ravindran *et al.*, 1982 and Eggum, 1970

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Enhancing the Usage of Cassava Products in Monogastric Animal Feed: A veritable tool to Food Security in Nigeria: A Review

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ABSTRACT

The high cost of conventional sources of energy like maize and sorghum for monogastric animal production has led to search for alternative low cost energy sources. This assessment was carried out to investigate the potential value of cassava products as feed ingredient for non-ruminant animals. The starchy roots produced in many tropical areas constitute an important energy source for human and animal feeding. Studiesshow that most of these cassava products are uncommonly used as feed for non-ruminant animals; this could be as a result of low protein content and high anti-nutritional factors. However, processing methods like sun-drying, boiling, ensiling, soaking and fermentation are engaged to improve their utilization in non-ruminant feed. Thoroughly processed cassava products could replace maize in non-ruminant diet at certain levels provided adequate protein supplement is used.

INTRODUCTION

In Nigeria today, concern of the rather low level of animal protein consumption has been generally occasioned mainly by low production level due to high cost of inputs. This low production is further aggravated by the outrageous demand for even the limited livestock products, leading to escalated costs. In monogastric animals like poultry, rabbits and pigs, feedstuff represents 65 to 70% of the total cost in an intensive production system in developing countries (Ekwe *et ai., 2021*). Energy source constitutes between 45 to 60% of finished feeds for these animals. The increasing pressure on the use of maize and other grains by man, livestock and industries makes it scarce and costly. The high cost has led to the need to explore alternative feed ingredients that are cheap and readily available which can also meet the nutrient requirements of livestock. Cassava products like foliage/leaves, stem and root are recognized as cheaper carbohydrate and protein sources than grains. They have high caloric yield and low production cost per hectare (Hahn, 1990). Their by-products such as peels, leaves and foliage are non-competitive feed materials that can be developed as components of feeds (Apata and Babalola, 2012).

Potentials of Cassava Products as Non-Ruminant Animal Feed

Cassava Peel: There is a great deal of interest in supplementing feeding of animals with cassava in Africa (Hahn, 1990). Cassava peel which is slightly richer in protein (2-3%) than the edible portion of cassava (1-2%) (Aina, 1990) could partially replace maize grains if adequately furnished with protein sources. The cassava peel will require a conscious supplementation of both methionine and dietary fat. About 5% palm oil will be useful for dietary cassava peel beyond the 30% level in the ration. According to Esonu and Udedibie (1993) cassava peel meal significantly depressed feed intake of rabbits at 100% replacement level for maize which could be as a result of high fibre and low energy content of the diet. They concluded that the optimal replacement level of maize with dried cassava peel meal from the trial is 50% for weaned rabbits. Cassava peel meal could make up to 40% of ration of fryer rabbits without any deleterious effects on live performance, especially when fish meal was used (Ijaiya, 2001). Preliminary studies have so far shown satisfactory performances in finisher cockerels with up to 45 percent inclusion of cassava peel as a replacement for maize in their rations. Growing pigs fed on a diet containing 40 percent cassava peel and discarded small tubers have been observed to perform satisfactorily (Tewe and Oke; 1983). Indeed, pigs fed such rations produced leaner carcasses and showed and economy of feed conversion. Cassava peel has been used to replace maize as an energy source in the diets of growing pigs.

Composite Cassava Meal: This is a cassava based diet that comprises the roots, leaves and stems fed to livestock at certain ratio (Akinfala *et al*., 2003). According to Tewe et al, (2002) the nutrient composition, quality and digestibility of composite cassava meal could be used as a ration for monogastric animals. There was a significant increase in weight gain, feed efficiency and consumption when composite cassava meal-based diet replaced maize in the diets of broiler chickens (Akinfala, *et al.*, 2003).

Cassava Root Meal: Supplementation of cassava-based diets with methionine has yielded better result than maize based diet. It should be noted that besides methionine supplementation, careful control of energy-protein ratio is necessary for satisfactory results. Eshiet *et al.*, (1989) fed 0, 15, 30 and 45% cassava root meal, in isocaloric and isonitrogenous diets, to fryer rabbits. They observed that rabbits could tolerate up to 30% cassava root meal diet without adverse effects on feed intake and rate of growth. The 45% cassava root level, however, gave poor growth and utilization efficiency. Cassava root meal is also deficient in essential fatty acids (Raimondi *et al*., 1983). It has been demonstrated that satisfactory feed intake and live weight gain was achieved when pigs were fed ad-libitum on freshly chopped cassava and different protein supplements (Hector, 2000). Cassava can fully replace cereal in pig diet without any negative effect when the diets are properly balanced. Further studies with pigs by Hector (2000) showed that cassava-based diet were clearly superior to wheat, barley and corn in terms of live weight gain, feed efficiency and bio-economics of production. To overcome cyanide toxicity in pigs sun-dried cassava meal-based diet was confirmed to be better than fresh root tubers. However, cassava based ration presented in mash were generally disliked by pigs. Pelleted cassava diets were more readily accepted by pigs than the conventional corn based diets. However, due to low protein content of cassava root relative to that contained in maize grain, replacement of dietary maize with cassava usually results in wide protein deficits in such diets. Thus, the enhancement of cassava root meal protein allows its favourable comparison with maize grain on qualitative basis (Ikurior and Akem, 1998).

Cassava Leaf/Foliage: is another new emerging protein source for livestock. The green nature of cassava leaf suggests it for better source of protein, vitamins and minerals. It is possible to obtain from cassava leaves more than 6 tons of crude protein per hectare a year with the proper agronomic practices directed towards foliage harvesting (Huy et al., 1995). The total essential amino acid content of cassava leaf protein is similar to that found in hen’s egg and is greater than that in oat and rice grain, soybean seed, and spinarch leaf, while the vitamin content of the leaves is high. Cassava leaves are rich in protein. According to Rogers and Milner (1983) the amount of protein (dry basis) ranges from 17.8 to 34.8 percent. It is important to note that when cassava leaves are sun-cured or dehydrated, most of the HCN is liberated and no toxic effects are therefore found when the leaves are consumed by animals. Cassava leaves therefore could be used as a source of protein for livestock in the tropics. Gomez et al., (1986) showed that broiler can tolerate a level of 15% cassava leaf meal without negative effect on their growth. According to Ranvindran (1991) nitrogen balance in growing pigs fed a cassava root meal diet is unaffected when cassava leaf meal replaces up to 35% of the protein from soybean meal.

CONCLUSION

It has established that cassava products possesses enormous potentials for use in replacement of the scarce and high priced maize in production of livestock feeds. This fact promises increased production of livestock, and by extension increased availability and consumption of animal protein if employed into use. Through this, cassava products could also contribute significantly to the protein of Nigerians thereby enhancing both household and national food security.

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Haematology and serum biochemistry of chicken fed cocoyam-based diet that was pre-treated with fungicides prior to planting.

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ABSTRACT

Cocoyam tubers were selected from those harvested from the experimental fields of NRCRI (National Root Crops Research Institute), Umudike. The cocoyam was processed into flour. Then the three groups of cocoyam; The processed Tecto-40EC treated cocoyam, the processed Benomyl treated cocoyam and the processed non - treated cocoyam flour were used to compound feed according to the standard technique and a selected commercial feed was used to compare the outcome. 36 day-old broiler chicks were divided into four groups and used for the experiment. The packed cell volume of the birds of the two controls, CC (non treated cocoyam diet) and Com.F (commercial feed diet) present a comparable result statistically 36.3% and 34.7% respectively. Whereas the CC group gave a better result generally than the Com.F group. Although there is a slight significance across the packed cell volume 40.0% and 37.7% respectively and the red blood cell indices (Mean corpuscular value, MCV) of the Benomyl treated cocoyam-based diet (CB) and Tecto-40EC treated cocoyam-based diet (CT), the result (90.0fl and 90.7fl respectively) compared favourably for the two control groups. When compared across the groups, the red blood cell indices are normocytic normochromic. Pre-treatment of cocoyam before planting to avoid pest and diseases did not present any adverse effect on the haemogram and blood biochemistry of the chickens fed cocoyam-based diet. This could be due to the drying methods used. Hence, pre-treatment prior to planting of cocoyam should be practiced. Supplementation of cocoyam flour in chicken feed can reduce cost of feed and increase the profit of the farmers. This is especially valuable to explore further in the supplementation of chicken feed in the advent of rising cost of maize used for feed formulation. This findings further confirms that cocoyam is rich in nutrients and can be of value in small household and in poultry

Key words: chicken, haemogram, cocoyam and blood biochemistry.

INTRODUCTION

Colacasia esculenta (L). Schott (cocoyam) is a perennial tropical plant primarily grown as a root vegetable for its edible, starchy corms. The plant has rhizomes of different shapes/sizes and is widely naturalized. The tubers are peeled, dried and ground into floor for pastry that can be stuffed with meat or other fillings. Thus, some varieties of this tuber crops can provide a substantial contribution to nutritional requirements, not only for energy but also for protein and minerals (Adelekan, 2012).

Feed alone accounts for 70% in livestock production. In Nigeria today, the cost of maize which constitutes the bulk energy source for livestock feed continues to soar high, making the cost of feed in the market to as well rise hence, the need for other alternatives. Such alternatives therefore include cocoyam root, peel and leaf meal. Cocoyam is a tuberous root that serves primarily as a source of carbohydrate and can completely replace maize as an energy source in feeds for poultry and other livestock.

In the planting of this root crop, many times there are incidences of fungal attack on the crop. This affects the yield of this root crop hence, the use of various fungicides to improve the yield. The objectives of this study were; to ascertain if the pretreatment of the cocoyam with two types of fungicide will negatively affect the haematology of chicken fed such pretreated cocoyam-based diet, to ascertain if the pretreatment of the cocoyam with two types of fungicide will negatively affect the serum biochemistry of chicken fed such pretreated cocoyam-based diet, to compare the effect with non – treated cocoyam based diet vis a vis a selected commercial feed.

MATERIALS AND METHODS

Sample collection and Preparation: Cocoyam tubers were selected from those harvested from the experimental fields of NRCRI, Umudike at 9 months after planting. The tubers were hand peeled using stainless steel knife, washed thoroughly and sliced into tiny pieces. The sliced samples were placed on a stainless steel tray and sun-dried for 5 days. The dried chips were grinded using a Warren blender to convert into flour. Then the flour was placed in polythene bags, packed and kept in desiccators until analysed for contents of proximate, minerals and anti-nutritional factors.

Then the three groups of cocoyam; the processed Tecto-40EC treated cocoyam, the processed Benomyl treated cocoyam and the processed non - treated cocoyam flour were used to compound feed according to the standard technique. Then a selected commercial feed was procured to make it four groups. 36 day - old broiler chicks were procured, stabilized for three weeks and afterwards divided into four groups were subjected to the experiment.

Determination of Proximate and Mineral Composition: Proximate compositions (total moisture content, crude fat, crude protein, crude fibre, ash, total carbohydrate and gross energy values) as well as the mineral compositions were determined using the procedures described by the Association of Official Analytical Chemists (AOAC, 2005). Analyses of the anti-nutritional factors were carried out by the method described Fana et al, 2015.

Statistical Analysis: A comparative analysis was conducted to prevent the difference in proximate compositions, mineral contents and antinutritional factors of the Benomyl and Tecto-40 EC treated and non-treated samples. The analyses of the haematology and serum biochemistry were performed using SPSS Version 23. Difference in means at $P \leq 0.05$ was considered significant. The data obtained from the study were summarized and represented as means=±SD. Statistical analysis of the treatment groups were made using statistical package for social sciences (SPSS).

RESULT AND DISCUSSION

Table 1: HAEMATOLOGY OF BROILERS AT DAY 21

GROUP	RBCx10^6	PCV (%)	HB (g/dl)	WBCx10^3	PLATELET	MCV (fl)	MCH (pg)	MCHC (g/dl)
CB	$3.1\pm0.3^{a*}$	28.0 ± 1.0^a	8.1 ± 0.2^a	36.7 ± 0.8^a	111.0 ± 6.3^{NS}	89.2 ± 0.0^a	25.5 ± 0.0^a	28.6 ± 0.0^a
CC	3.8 ± 0.1^b	34.3 ± 1.5^b	8.4 ± 0.1^a	38.2 ± 0.7^{ba}	114.0 ± 5.3^{NS}	90.7 ± 0.0^b	22.5 ± 0.1^b	24.7 ± 0.0^b
CT	4.0 ± 0.1^c	36.3 ± 1.2^b	9.2 ± 0.3^b	36.1 ± 3.2^{abd}	103.0 ± 2.0^{NS}	88.6 ± 0.0^c	22.8 ± 0.0^c	25.7 ± 0.0^c
COM.F	3.6 ± 0.0^d	31.3 ± 1.2^c	8.2 ± 0.2^a	34.4 ± 41.3^{da}	105.7 ± 7.5^{NS}	90.1 ± 0.0^d	23.1 ± 0.0^d	25.6 ± 0.0^d

Different superscript indicates significance *Standard deviation, **P≤0.05,** NS=Not significant, RBC=red blood cells, PCV=packed cell volume, Hb=Haemoglobin, WBC=White blood cell, MCV=mean corpuscular volume, MCH=Mean corpuscular haemoglobin, MCHC=Mean corpuscular haemoglobin concentration. CB=Benomyl treated cocoyam based meal, CC= Non treated cocoyam based meal, CT= Tecto-40 EC treated cocoyam based meal, COM.F= commercial feed.

There is significant difference across the four groups in red blood cells, RBC, CT is significantly higher to CC, CC is significantly higher to Com. F and Com. F is significantly higher to CB. The PCV result had significant difference across groups. Group CT is higher followed by CC, Com.F and CB in that order. The Haemoglobin values were similar with groups CB, CC and Com.F and these three were significantly lower to CT (9.2±0.3). WBC were similar across groups CB, CC and CT but significantly lower to Com.F Platelets were similar across the groups. The RBC indices (MCV, MCH and MCHC) had significant differences across the four groups. (Table 1).

Table 2: WHITE BLOOD CELL DIFFERENTIALS OF BROILERS AT DAY 21

GROUP	NEUTROPHIL	LYMPHOCITES	MONOCITES	EOSINOPHILS	BASOPHILS
CB	36.7 ± 1.5^a	52.7 ± 1.2^a	6.7 ± 0.6^a	4.0 ± 0.0^a	0
CC	37.7 ± 1.2^a	54.3 ± 1.5^{ba}	4.7 ± 0.6^b	3.3 ± 0.6^{ba}	0
CT	36.0 ± 1.0^a	56.7 ± 1.5^{cb}	4.0 ± 1.0^b	3.3 ± 0.6^{ba}	0
COM.F	40.3 ± 1.5^b	51.3 ± 1.5^{da}	5.3 ± 0.6^b	3.0 ± 0.0^{cb}	0

Different superscript indicates significance *Standard deviation, **P≤0.05,** NS=Not significant, CB=Benomyl treated cocoyam based meal, CC= Non treated cocoyam based meal, CT= Tecto-40 EC treated cocoyam based meal, COM.F= commercial feed.

WHITE BLOOD CELL DIFFERENTIALS OF BROILERS AT DAY 21

Neutrophil is similar with CB; CC and CT but significantly lower to Com.F. Lymphocyte is similar in CB and CC. CC is similar to CB and CT. Com.F is similar only to CB. Eosinophil is similar in CB, CC and CT. Com.F is similar only to CC. (Table 2).

Table 3: BLOOD BIOCHEMISTRY OF BROILERS AT DAY 21

GROUP	TC	HDL	TAG	TP (g/dl)	AST	ALT	ALP	LDL	VLDL

CB	72.4±0.5^{a}	33.1±0.3^{a}	76.8±1.4^{a}	2.6±0.1^{a}	24.7±1.5^{a}	18.7±1.2^{NS}	45.0±3.0^{a}	15.7±0.0^{a}	24.1±0.0^{a}
CC	71.4±0.8^{a}	34.8±0.2^{b}	73.6±0.7^{b}	2.4±0.1^{b}	25.0±1.0^{a}	22.0±1.0^{NS}	40.3±1.5^{bc}	14.6±0.0^{b}	22.3±0.0^{b}
CT	69.4±1.1^{a}	32.4±0.4^{a}	79.4±1.1^{c}	2.4±0.0^{b}	25.7±2.5^{a}	22.0±3.6^{NS}	41.0±1.0^{ca}	15.9±0.0^{c}	20.7±0.0^{c}
COM.F	60.7±3.0^{b}	26.6±0.6^{c}	83.3±0.5^{d}	2.4±0.1^{b}	29.7±1.5^{b}	20.0±2.0^{NS}	52.0±3.0^{d}	16.7±0.0^{d}	16.6±0.0^{d}

Different superscript indicates significance *Standard deviation**,** TC=total cholesterol, HDL=high density lipoprotein, TAG=triacylglyceride, TP=total protein, AST=aspartate aminotransferase, ALT= alanine transaminase, ALP=alkaline transaminase, LDL=low density lipoprotein, VLDL=very low density lipoprotein. NS=Not significant, CB=Benomyl treated cocoyam based meal, CC= Non treated cocoyam based meal, CT= Tecto-40 EC treated cocoyam based meal, COM.F= commercial feed.

BLOOD BIOCHEMISTRY OF BROILERS AT DAY 21

Total cholesterol is similar among CB, CC and CT but significantly lower in Com.F. HDL is similar between CB and CT but significantly higher to CC. Groups CB, CC and CT were significantly higher to com.F. TAG is significantly difference across the groups. Total protein is significantly higher in CB than the rest of the groups which were similar. (Table 3). AST is similar among CB, CC and CT but were significantly lower to Com.F. ALT had no significant difference. In ALP, CB is similar to CT, CC is similar to CT but CB, CC and CT were significantly lower to Com.F. The LDL value of CB and CT are similar, CC is significantly lower to CB, CT and Com.F while Com.F is significantly higher to CB, CC and CT. In VLDL there is significant difference across the four groups. (Table 3).

Table 4: HAEMATOLOGY OF BROILERS AT DAY 42

GROUP	RBCx10^{6}	PCV (%)	HB (g/dl)	WBCx10^{3}	PLATELET	MCV (fl)	MCH (pg)	MCHC (g/dl)
CB	4.4±0.0^{a}	40.0±1.0^{a}	10.6±0.1^{a}	36.0±0.7^{NS}	116.7±1.5^{a}	90.7±0.0^{a}	24.1±0.0^{a}	26.5±0.0a
CC	4.1±0.0^{b}	36.3±0.6^{b}	9.6±0.1^{b}	36.5±2.6^{NS}	106.7±2.1^{b}	90.0±0.0^{b}	23.4±0.0^{b}	25.9±0.0^{b}
CT	4.2±0.1^{b}	37.7±0.6^{c}	10.3±0.3^{a}	34.4±0.6^{NS}	113.0±2.7^{ca}	90.5±0.0^{c}	23.8±0.0^{c}	26.3±0.0^{c}
COM.F	3.8±0.1^{c}	34.7±0.6^{d}	8.70.3^{c}	35.6±0.5^{NS}	110.7±2.1^{dc}	90.7±0.0^{da}	22.4±0.0^{d}	24.7±0.0^{d}

Different superscript indicates significance *Standard deviation, NS=Not significant, RBC=red blood cells, PCV=packed cell volume, Hb=Haemoglobin, WBC=White blood cell, MCV=mean corpuscular volume, MCH=Mean corpuscular haemoglobin, MCHC=Mean corpuscular haemoglobin concentration. CB=Benomyl treated cocoyam based meal, CC= Non treated cocoyam based meal, CT= Tecto-40 EC treated cocoyam based meal, COM.F= commercial feed.

There is significant difference in RBC between CB, Com.F and CC and CT. Cc and CT is similar. The PCV has significant difference across the groups with CB with the highest PCV. The Hb of CB and CT is similar and both significant differs from CC and Com.F. WBC values across the groups are similar. (Table 4). The Platelets of CB is similar to that of CT and are significantly higher than CC. CT is similar to Com.F but Com.F is significantly higher than CC. (Table 4). RBC INDICES: MCV is similar across the groups. MCH of CB and CT is similar and significantly higher than CC and CC is significantly higher than Com.F. MCHC of CB is significantly higher than CT, CC and Com.F.(Table 4).

Table 5: WHITE BLOOD CELL DIFFERENTIALS OF BROILERS AT DAY 42

GROUP	NEUTROPHIL	LYMPHOCITES	MONOCITES	EOSINOPHILS	BASOPHILS
CB	33.0 ± 1.7^{a}	58.3 ± 2.1^{a}	5.0 ± 1.0^{NS}	3.7 ± 0.6^{NS}	0
CC	37.0 ± 1.0^{b}	54.3 ± 1.5^{b}	4.7 ± 0.6^{NS}	4.0 ± 1.0^{NS}	0
CT	39.0 ± 1.0^{cb}	53.3 ± 1.2^{b}	4.7 ± 0.6^{NS}	3.0 ± 1.0^{NS}	0
COM.F	40.7 ± 0.6^{dc}	51.7 ± 1.2^{b}	4.0 ± 0.0^{NS}	3.7 ± 0.6^{NS}	0

Different superscript indicates significance *Standard deviation, **P≤0.05,** NS=Not significant, CB=Benomyl treated cocoyam based meal, CC= Non treated cocoyam based meal, CT= Tecto-40 EC treated cocoyam based meal, COM.F= commercial feed.

WHITE BLOOD CELL DIFFERENTIALS OF BROILERS AT DAY 42

Neutrophils of Com.F is highest and significantly different to CC and CB but similar to CT. Lymphocytes of CB is highest and significantly different from CC, CT and Com.F while CC, CT and Com.F are similar. Monocytes and Eosinophils are similar across their groups. (Table 5).

Table 6: BLOOD BIOCHEMISTRY OF BROILERS AT DAY 42

GRP	TC	HDL	TAG	TP (g/dl)	AST	ALT	ALP	LDL	VLDL
CB	83.0 ± 1.8^{a}	45.5 ± 0.5^{a}	87.5 ± 1.0^{a}	3.8 ± 0.0^{a}	30.0 ± 2.0^{a}	22.0±3.0 NS	50.3 ± 1.5^{a}	17.6 ± 1.1^{ac}	20.1±2.0
CC	96.8 ± 1.6^{b}	53.5 ± 0.5^{b}	85.9 ± 0.8^{ba}	4.1 ± 0.1^{b}	28.3 ± 1.5^{ba}	20.3±1.5 NS	46.0 ± 1.0^{b}	17.2 ± 1.1^{bac}	25.8±0.8
CT	77.3 ± 1.2^{c}	41.5 ± 0.5^{c}	89.2 ± 0.3^{ca}	3.2 ± 0.0^{c}	25.7 ± 0.6^{c}	21.3±1.5 NS	50.3 ± 1.5^{ca}	18.1 ± 1.4^{c}	17.8±0.1
COM.F	51.7 ± 1.9^{d}	28.5 ± 0.6^{d}	78.3 ± 2.2^{d}	3.1 ± 0.1^{c}	32.0 ± 1.0^{da}	19.0±1.0 NS	43.0 ± 1.0^{d}	15.7 ± 0.1^{da}	7.0 ± 0.1^{d}

Different superscript indicates significance *Standard deviation**,** TC=total cholesterol, HDL=high density lipoprotein, TAG=triacylglyceride, TP=total protein, AST=aspartate aminotransferase, ALT= alanine transaminase, ALP=alkaline transaminase, LDL=low density lipoprotein, VLDL=very low density lipoprotein. NS=Not significant, CB=Benomyl treated cocoyam based meal, CC= Non treated cocoyam based meal, CT= Tecto-40 EC treated cocoyam based meal, COM.F= commercial feed.

BLOOD BIOCHEMISTRY OF BROILERS AT DAY 42

Total cholesterol has significant difference across the groups. CC is highest followed by CB, CT and Com.F in that order. HDL has significant difference across the groups. CC is highest, CB, CT and Com.F in that order. In TAG, CB, CC and CT are similar and significantly higher to Com.F. Total protein of CC is significantly higher to CB and both are significantly higher to CT and Com.F. (Table 6). AST of CB, CC and Com.F are similar and are significantly higher to CT. ALT across the groups are similar. ALP of CB and CT are similar and significantly higher to CC and Com.F. CC is significantly higher than Com.F. LDL of CB, CC and CT were similar and significantly higher than Com.F. VLDL is significantly different across the groups. CC is the highest, followed by CB, CT and Com.F in that order. (Table 6).

RESULT AND DISCUSSION

The 21st day haematology of the birds of the two controls, CC (non treated cocoyam diet) and Com.F (commercial feed diet) present a comparable results. Whereas the CC group gave a better result generally than the Com.F group (Table 1). This is especially valuable to explore further in the supplementation of chicken feed in the advent of rising cost of maize used for feed formulation. This findings further confirms that cocoyam is rich in other nutrients not just energy source (given the result) and can be of value in small household and in poultry. This agrees with the findings of Nwankwo, (2021) but contrasted with Adelekan, (2012) who noted in his work that cocoyam is an energy rich food.

Although there is a slight significance across the haemogram and the red blood cell indices of the Benomyl treated cocoyam-based diet (CC) and Tecto-40EC treated cocoyam-based diet (CT), especially in the RBC, PCV, HB, MCV, MCH and MCHC, the result compared favourably to the two controlled groups. When compared across the groups, with the controls, the red blood cell indices are normocytic normochromic. (McGill, 2016., Sharma, 1990 and Bessman, et al 1983).

We therefore states that the pre-treatment of cocoyam before planting did not adversely affect the PCV and Hb of the chickens in this experiment (Onibi., 2011). The WBC across the groups did show leukocytosis. This is further confirmed in the WBC differential of the 21st day blood picture (Table 2). (Orawan and Aengwanich, 2007). The 21st day of age biochemical parameters across the groups significantly differed slightly. However, the total cholesterol of the three cocoyam-based diet (CB, CC and CT) gave a higher value that was significant compared to Com.F. This is of immerse health benefit in chicken feed and indirectly to human's health. Across the groups LDL, low density lipoprotein (bad fat) were similar indicating that the four diet were good in this area. The VLDL, very low density lipoprotein (very bad fat) was lowest in Com. F compared to the other groups. Although all values were within the normal range. This area may need further studies/ investigation by our breeders/ biotechnologists. Other parameters across the groups were similar. Lipoproteins are a combination of proteins and fats found in the blood of mammals. They are categorized based on their density. Very low-density lipoprotein is regarded as bad cholesterol. VLDL and LDL are generally considered more harmful than high density lipoprotein (HDL). (Jeffrey, W., 2021).

The 42nd day haemogram (Table 4), RBC indices were essentially similar and within the normal range hence were normocytic normochromic. CC group gave the lowest platelet counts compared to other groups. However, the value falls within the normal range. The WBC across the groups were not significantly different, indicating that there was a normal playing ground across the group. The RBC, PCV and HB across the groups were slightly different. (Onibi., 2011). In day 42nd day blood biochemistry (Table 6), the biochemical parameters showed significance in the TC across the four groups and com. F was the least. The HDL, high density lipoprotein (good fat) of the three cocoyam-based diets gave slightly higher value compared to Com.F diet. This is an advantage for the cocoyam-based diets. The VLDL, very low density lipoprotein (bad fat) had the CB, CC and CT groups slightly higher than Com. F. This trait need to be further investigated and genetically re-engineered to improve the make-up of the cocoyam based diets. Other biochemical parameters across the groups were similar.

CONCLUSION AND RECOMMENDATION

Pre-treatment of cocoyam before planting to avoid pest and diseases did not present any adverse effect on the haemogram and blood biochemistry of the chickens fed cocoyam-based diet. This could be due to the drying methods used. This agrees with earlier worker, (Fana, et al., 2015). Hence, pre-treatment prior to planting of cocoyam should be practiced. Supplementation of cocoyam flour in chicken feed can reduce cost of feed and increase the profit of the farmers

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Performance Of Growing Wad Goats Fed Graded Level Of Rice Bran In Pelleted Dried Cassava Peel Based Diet

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ABSTRACT

The concern of selective picking of non-conventional feedstuffs by goat has necessitated the need for pelleting the feedstuffs mixture for indiscriminate intake and performance. Hence, twelve growing goats of similar weight range from 5 to 6 g were used to determine the effect of pelleting graded level of rice bran n cassava peels based diet for goat performance and blood evaluation. Four diets were formulated; diet 1 contained 0% rice bran and 100% dried cassava peel, diet 2 contained 15% rice bran and 85% dried cassava peel, diet 3 contained 25% rice bran and 75% dried cassava peel, and diet 4 contained 35% rice bran and 65% dried cassava peel. A total of twelve (12) West African Dwarf goats were randomly allocated to the four diets, with three animals per diet, each serving as a replica. The parameters assessed were feed intake, water intake, weight gain, feed conversion efficiency, and blood hematology and serum biochemistry such as parked cell volume (PCV), white blood cell (WBC), red blood cell (RBC), Hemoglobin (HB), total protein (TP), albumin (ALB), globumin (GLOB), alanine aminotransferase (ALT), alaline phosphatase (ALT), aspartate aminotransferase (AST), cholesterol (CHOL), creatinine (CRET. The results showed that pelleting rice bran with cassava peel n goat diet generally enhance rice bran intake and utilization. The intake of rice bran increased (p.0.05) increased as rice bran inclusion increased from diet 1 to 4. Total feed intake reduced (p>0.05) with least value (15.17kg) obtained on diet diet 4. However, total weight gain, average weight gain increased (p>0.05) with increased rice bran inclusion in the det. The value ranges from 0.33 to 1.17 for weight gain and 0.005 t0 0.017kg for average weight gain respectively. The feed conversion ratio increased (p>0.05) with increased rice bran n pelleted diet. Animals on Diet 4 showed lowest value (12.98) that indicated highest efficiency. Animals on det 4 recorded highest PCV value (31.67) but similar to value from animal maintained on diet 3. RBC and HB were similar (p>0.05) for all treated groups and WBC values were comparable (p>0.05) but those on diet 1 had least value (9.23). Serum biochemistry responses of goat fed indicated comparable values (p>0.05) as rice bran inclusion increased. The values of TP and ALT indicated similarity for all treated animal groups and animals maintained on diets 3 and 4 that contained high grade levels of rice bran displayed similarity (p>0.05). Pelleting of rice bran with cassava peels improved consumption and

conversion ratio and thereby enhancing the performance of growing goats and thus proved its efficacy up to 35% inclusion.

Key words: Pelleting; Race bran; cassava peel; heamatology, serum; weight gain; growing WAD goat.

INTRODUCTION

Goats are among the relatively few ruminant species in the animal realm. They only have five (5) basic dietary requirements: crude protein, energy (in the form of fiber), fat, and water-soluble vitamins and minerals is required because concentrated ingredients like maize are food for humans (Morais et al., 2020). According to (Kalio et al., 2018), even while forage crops provide for superior ruminant feed, they are not always accessible. As a result, these NCFRs are fed to the animals in their place. In this environment, goats have a diverse diet that includes many non-conventional feedstuffs. Given that goats are very selective feeders and switch from a diet that consists mostly of forbs (8–64%) to browse (35–88%), it is thought that this may also apply to concentrates (Mellado., 2016). The eating habits of these dwarf goats are typical of the local husbandry method in which they scrounge for food to satisfy their daily nutritional needs (Daramola et al., 2005). But since there isn't nearly enough green vegetation for these natural browsers, particularly during the dry season, attempts s been undertaken to encourage goats in this ecozone to consume the abundant non-conventional feedstuffs such as rice bran that are always present. The shortage of good quality feeds to sustain ruminant animals during dry season has being a challenge to the ruminant production as reported by Ososanya, et al., 2013. On this note, a feeding strategy is required to gear up the consumption of inexpensive, unpalatable and readily available feed resources in the mixture without selection. Rice bran which stand better chance of effective and efficient utilization during feed scarcity because of the availably and storability. Hence, the focus of this study s to assess the effectiveness of pelleting technique on intake and performance of growing goats fed rice bran n pelleted cassava based det.

MATERIALS AND METHODS

Study location

The location of this study was the sheep and goat unit of Teaching and Research Farm, Landmark University, Omu –Aran, Kwara State, Nigeria. The coordinates of Omu-Aran are Latitude 8.9N and Longitude 50.61E and is on approximate altitude of 306above sea level. The temperature is uniformly high and range between 250^{0}C and 300^{0}C in the wet season and between 330^{0}C and 340^{0}Cin dry season. The relative humidity is 75 to 80% in the wet season and about 65% in dry season.

Experimental diet

Mechanical grinder was used to grind dry cassava peel to sizes. The four formulated diets used in this study were formed by replacing the proportion of grinded cassava peels with rice bran, mixed thoroughly with hand and pelleted using mechanical pelletizer of die 8mm size thus; Pelleted diet 1 contained 100% cassava peel and 0% Rice bran; The pelleted diets 2, 3 and 4 contained 15, 25 and 35% rice bran respectively that replace equivalent proportion of cassava peel. (Table 1) Equal measured quantity of feed additives were added to each of the 4 diets prior mixing and each diet had molasses that served as binding agent as well enhancer of the energy.

Table 1: The composition of pelleted diet

Ingredient	Diet 1	Diet 2	Diet 3	Diet 4
dried cassava peel(kg)	100	85	75	65
Rice bran(kg)	0	15	25	35
Total	**100**	**100**	**100**	**100**
Constant additives				
Molasses (kg)	5	5	5	5
bone meal (kg)	1	1	1	1
Salt (kg)	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25

Experimental animals and management

A total of 12 growing WAD goats were used. The growing goat aged 5 to 6 with initial average weight of 6kg. Each treatment comprised three replicates. Animals were treated with ivermectin subcutaneously against both ecto and endo parasites. Long acting injectable oxytetraycline was intramuscularly administered against bacterial infections before the commencement of the trial. The weight of the animals were taken before the takeoff of the trial to established the initial body weight and thereafter they were weighed weekly through the trial period. Experimental diets were served once daily at 8.00 hours in cleaned feed trough at 5% body weight on dry matter basis through the seventy (70) days of the experiment that included first 7 day adjustment period. Clean water and salt licks were also made available throughout the study time. Parameters assessed include; body weight, feed intake and feed conversion efficiency. Feed efficiency was calculated by dividing the feed intake by weight gain

Haemmtology and serum biochemical indices analyses

The blood was evaluated at the end of the trial. Two animals per dietary treatment were randomly picked for blood sample collection. 10mls of blood sample was collected via jugular venipuncture using 20 gauge needle and syringe on the final day of a ten-week experimental study. Each blood collection was divided to 2 lots; one part was transferred to Ethylene Diamine Tetracetic Acid (EDTA) bottles that contained anticoagulant for haematological assay (jain 1986) and other part free bottles that contain no anticoagulant for serum assessment. The samples were taken to university of Ilorin Central Laboratory where it was analyzed according to available clinical methods. Packed cell volume (PCV), Haematoglobin (HB), RBC, WBC, Mean corpuscular volume (MCV), Mean corpuscular haemoglobin concentration (MCHC), Cholesterol, Albumin, Total protein, Globulin WBC differentials; Monocytes, Neutrophils among others were assessed. The PCV was determined with wintrobe haematocrit method, Wintrobe (1993). WBC and RBC were determined using haemocytometer after the necessary dilution (Dacie and Lewis, 1994). Haemoglobin, Mean corpuscular volume (Brown . 1976). Cholestero was measured (Roshlan SIGMA Kits (Feteris, 1965).

Statistical analysis

Dara obtained were subjected analysis of variance with SAS General model (2000) and means were separated at p>0.05 using New Duncam Multiple range test (Obi, 2002)

RESULTS

Table 2: Proximate composition of experimental diets

	0%rice bran (Diet1)	15% rice bran (Diet2)	25% rice bran (Diet3)	35% rice bran (Diet4)	SEM ±
DM (%)	92.50^{a}	91.33^{a}	92.43^{a}		0.56
MC (%)	7.50^{a}	8.67^{a}	7.57^{a}	7.89^{a}	0.02
CP (%)	0.27^{c}	4.41^{ab}	5.11^{a}	4.91^{b}	0.58
EE (%)	4.50^{b}	2.40^{c}	6.0^{a}	5.24^{ab}	0.43
CF (%)	7.50^{ab}	8.46^{b}	9.01^{a}	9.50^{a}	2.24
ASH (%)	5.30^{b}	6.93^{a}	4.44^{bc}	3.49^{c}	0.41
NFE (%)	61.37^{c}	69.38^{b}	71.47^{b}	78.39^{a}	1.90

a,b= Means in the same row having different superscript differs significantly (P< 0.05).
DM-Dry matter, MC-Moisture content, CP- Crude protein, EE-Ether extract, CF- Crude fibre, ASH- Ash, NFE- Nitrogen free extract.

The proximate composition of the feed utilized is shown in Table 2. The DM mean values of the feed was similar across treatments. The CP mean value of diet 3 is higher and different(P<0.05) among the treatment means, but comparable (p>0.05) to CP value of diet 4 while the MC mean value increased with the addition of rice bran in the pelleted diet compared to diet 1, which contained no rice bran but value were similar (p>0.05). The fat mean value of diet 3 was the highest among the treatments and significantly different (P<0.05s) but comparable (p>0.05) to the mean value of diet 4. However more fat was recorded as rice bran inclusion increased in the diets. The highest crude fibre was recorded in diet 4 (35% rice bran inclusion ration} but the values across the treatment were comparable (p>0.05)

Table 3: performance of growing WAD goats fed pelleted rice bran-dried cassava peel diet

Parameters	DIET1	DIET2	DIET3	DIE 4	SEM±
Total feed intake (kg)	19.93^{a}	20.55^{a}	14.93^{b}	15.17^{b}	0.86
Average daily feed intake	0.28^{a}	0.29^{a}	0.21^{b}	0.22^{b}	0.01
Total water intake(ml)	22516.7b	27066.65b	31850ab	31616.70a	118.60

Daily water intake (ml)	2251.67b	2706.67b	3185ab	3161.67a	10.60
total weight gain(kg)	0.33[a]	0.67[a]	0.67[a]	1.17[a]	0.17
Average daily weight gain (kg)	0.005[a]	0.010[a]	0.010[a]	0.017[a]	0
feed conversion ratio	60.39[a]	30.67[b]	22.28[bc]	12.98[b]	6.18

a,b= Means in the same row having different superscript differs significantly (P< 0.05)

Table 3 shows the performance of the growing WAD goats fed graded levels of rice bran in pelleted dried cassava diets. The total feed intake mean value followed the same trend with FCR. The values decreased as rice bran inclusion increased comparable (p>0.05) for diet 3 and 4 mean values were equally similar (p>0.05). The water intake mean value of diet 4 was significantly different (p<0.05) among the treatment means but comparable to the mean values of diet 3.Total water intake of diet 1 and 2 were similar (p>0.05) and were comparable to the mean value of diet 3 weekly water intake and daily water intake mean followed the same trend.

Table 4: **EFFECTS OF DIFFERENT LEVELS OF THE RICE BRAN IN THE CASSAVA-RICE BRAN PELLETED RATION ON THE BLOOD**

Parameters	DIET1	DIET2	DIET3	DIET4	SEM ±
PCV (%)	26[ab]	21.33[b]	30.33[a]	31.67[a]	1.60
WBC (X109/L)	9.23[b]	10.40[a]	9.37[b]	9.8[ab]	0.16
RBC (X1012/L)	2.7	2.33	2.6	2.74	0.69
HB (g/L)	29.33	24.40	24.77	27.30	1.40
PLAT (X109/L)	180.67	181	183.33	179.67	1.51
MCV (fl)	10.13	9.47	10.33	10.17	0.20
MCH (pg)	10.44[a]	7.79[b]	10.01[a]	10.57[a]	0.36
MCHC (g/dl)	10.63[a]	9.4[c]	10.06[b]	10.33[ab]	0.15
LYMPH(%)	44.67	43	43	40.67	0.93
NEUTR(%)	55.67	59	58.33	54.33	0.89
MONOCY(%)	0	0	0	0	0
EOSIN(%)	0	0.33	0.33	0.33	0.13
BASO(%)	0.33	0	0	0.33	0.11

a,b= Means in the same row having different superscript differs significantly (P< 0.05)

Legend: PCV= Packed cell volume, HB= haemoglobin, MCH= mean corpuscular haemoglobin, MCHC= mean corpuscular haemoglobin concentration, MCV= mean corpuscular volume, RBC= red blood cell, WBC= white blood cell, NUET= Neutrophils, LYMPH=. Lymphocyte,PLAT=platelets

Table 4, it shows the haematology parameters evaluated, the PCV mean values of diets 4 and 3 are similar (P>0.05) while the means of diet 2 was significantly different (P<0.05) among the treatments. The PCV mean value increased with increased rice bran in the pelleted ration. However, the values obtained (21.3-31.7) fall within the range reported by (Charles Magi 2007). The RBC values for all treatments shows no significant difference (P>0.05) and the mean value increased as rice bran increased in the pelleted ration. However, the values that range between (2.33-2.7) obtained in this research were higher than value reported by Daramola *et al.,* 2005 for healthy goat. The Haemoglobin (Hb) result followed the same trend as RBC. The mean value increased as the rice bran increased in the pelleted ration. The Hb obtained values in this study (2.4-29.3) were higher than (11.88-12.20) reported by (Odoemelen, 2014) for healthy goats Concern the WBC, the mean values indicates reduction as the rice bran increased in the pelleted ration, However, there was observable similarity (P>0.05) means of diets 1, 2 and 3 without any observable harmful nutritional effect on the status of the animals treated animals. The MCV mean values increased as the rice bran increased in the diet, however, the mean values are similar (P>0.05). The MCH mean values increased as the rice bran increased in the pelleted ration but the mean value of diet 1 (dried cassava peel only), diet 3 and 4 were similar (P>0.05) .The MCHC also increased as the rice bran increased in the pelleted ration but diet 3 and 4 mean values were comparable.

Table 5: EFFECTS OF DIFFERENT LEVELS OF THE RICE BRAN IN THE CASSAVA-RICE BRAN PELLETED RATION ON THE BIOCHEMICAL INDICES

Parameters	DIET1	DIET2	DIET3	DIET4	SEM ±
TP (G/L)	33.67	34.33	40	40	1.38
Alb (G/L)	18.67^{b}	21.93^{ab}	24.33^{a}	22.43^{ab}	0.8
Glob (G/L)	16.33^{ab}	14.10^{ab}	17.70^{a}	13.83^{b}	0.68
Creat (µMOL/L)	27^{b}	31^{ab}	33.33^{a}	32.33^{a}	0.98
Chol (MMOL/L)	1.65^{a}	1.56^{ab}	1.38^{b}	1.45^{b}	0.39
ALP (IU/L)	235.67^{ab}	231.67^{b}	246.67^{a}	249.33^{a}	2.90
AST (IU/L)	67.87^{a}	58.87^{ab}	48.47^{b}	52.43^{b}	2.87
ALT (IU/L)	20.33	67.73	13.5	12.23	12.46

^{a,b}= Means in the same row having different superscript differs significantly (P< 0.05)

Legend: CHOL= Cholesterol, CRT= Creatine, TP= Total protein, GLOB= Globulin, ALB= Albumin ALP=Alkaline Phosphate, AST= Aspartate Aminotransferase ALT= Alanine Transaminase

Table 5, shows the result of biochemical indices of goat treated; the total protein mean values indicates no significant difference (P>0.05), but the value increased as rice bran increased in the pelleted ration. The result also shows that all animals responded equally. The Albumin means showed that diet 3 is significantly different (P<0.05) from the mean value of diet 1. However, diet

3 mean is comparable with diet 2 and 4.The result also shows increase in the mean values of the albumin as the rice bran in the diet increases in the pelleted ration. The Globulin mean values increased from diet 3 to 4 but indicates significantly different (P>0.05), however they are comparable (p>0.05) to mean values of diets 1 and 2. Creatinine mean values for diet 3 and 4 are similar (P> 0.05) but value of diet 1 is significantly different (P>0.05) from values of diet 3 and 4 and comparable to values from diet 2. As reported by (Rahardja *et al.*, 2000) Goats have a clear relationship between body weight and the total amount of creatinine in their blood and urine. The ALP mean values increased as the rice bran in the pelleted diet increased, however the mean values of diet 3 and 4 were similar(P>0.05), while diet 2 is significantly different (P>0.05) from diet 3 and 4, but diet 1 is comparable (p>0.05) to diets 2,3 and 4.

DISCUSSION

Tables 1 and 2 shows the composition and nutrient composition of the experimental diets respectively. Cassava peel could be taken to represent the array of low protein and low energy crop residues as reflected in the calculated NFE obtained value of 61.37% for diet 1(pelleted cassava peel only) and 78.39% for diet 4 (diet that contained 35% rice bran in pelleted dried cassava peels used-this study contained 0.27%CP and 4.50%EE with a calculated NFE of 61.37%). These values fall within earlier reported ranges (Asaolu and Odeyinka, 2006). However, Norton (1994) reported that feeds containing less than 8% CP could not provide the ammonia levels required by rumen microbes for optimum activity. (Yousef *et al.*, 2007) opined that relatively high ADF but low EE and CP content were suggestive of low nutritional quality. In this study ,the nutrient content of all the pelleted experimental diets (2-4) increased with the addition of rice bran in the pelleted ration, and these results were in agreement with earlier reports (Asaolu and Odeyinka, 2006; Asaolu *et al.*, 2010). The CP of pellet rations was lower than the 8% level required for optimum microbial activity (Norton, 1994). If the values are also lower than the 11% to 13% known to be capable of supplying adequate protein for maintenance and moderate growth in goats (NRC 1981). However, the results indicated improvement in the nutrient availability for the experimental as the rice bran increased in the ration, which in turn was reflected in the increased feed intake and moderate weight gains. (Fredric N. Owens and Robert B. Hicks, 2019) narrated in their book that if a growing animal is provided with insufficient protein, the efficiency with which the animal will utilize metabolizable energy will probably be altered. This is what was observed and noticed as the rice bran inclusion in the pelleted diet increased. The noticed improvement in the feed intake, water intake, and weight gain by the animal fed with these pelleted rice bran in dried cassava peel diet is suggestive of the suitability of pelleting of rice bran in a dried cassava peel based diet for growing goats. All the experimental animals had adequate total feed intake. There was also an observed variation in the total feed intake with increasing rice bran in the pelleted ration. The lowest level of intake (15.17kg) of the animal in diet 4 may be due to the fact that the feed value for ruminants lies in its palatability. The variation observed may also have been due to the CP level of the diet, as indicated in the report by Mtenga & Shoo, 1990), which states a positive correlation between crude protein intake and dry matter intake . The experimental goats in this study gained weight as rice bran increased in the pelleted diet. This observation was translated to an improvement in the final weight gain of the animal, probably as a result of the duration of the study (10 weeks). Although the values obtained in this study were lower compared to the values reported by authors like (Babayemi *et al.*, 2006, and Odeyinka, 2001). However, the observed difference in weight gain with earlier studies could have been due to differences in the basal components of the diet, voluntary dry matter intake, feed intake, efficiency of feed utilization and the physiological state of the animal with increasing rice bran inclusion. Animals in diet 4 (35% rice bran inclusion) were indicated to be more efficient in converting feed to weight gain than those on less bran inclusion (diet 1-3).An earlier similar observation was reported (Tripathi *et al.*, 2006) between growth and feed conversion. The observed increased weight gain as rice bran increased could further be attributed to the better quality protein available in the nutrition. The increase in PCV, RBC AND the Hb as the inclusion percentage of rice bran increased in the dried cassava pelleted diets, can be compared to the literature value showing the animals used for the study may not be prone to anemia. The high concentration of RBC and haemoglobin values obtained across these treatments, indicated the absence of toxic factors such as haemoglobin which has adverse effects on the blood formation as proved by (Akinmutimi 2004)for some exotic goats. The MCV and MCH values obtained in this study were comparable to 5-8pg for MCH and 16-25fl for MCV reported by (Charles Magi 2007). The mean value of RBC increased as the rice bran increased in the diets, this could be as a result of good ratio of haemoglobin to the PCV since both haemoglobin and PCV were higher than the PCV (21-38%) reported by (Charles Magi 2007), and 7-15g/dl and 11.88 – 12 g/dl for Haemoglobin reported by (Daramola,*et al*., 2005). The mean values of creatinine increased as the rice bran increased in the pelleted ration and which indicated similarity value statistically was a reflection of good protein quality resulted from the pelleted rations as reported by (Aletor *et al*., 1998). The reduction in creatinine values as the rice bran increased in the diets reflected the ration quality and proved that the tested animals were not prone to muscular wastage. (Aletor *et al.,* 1998).

CONCLUSION

The pelleting technique as undertaken in this study resulted in an adequate intake of rice bran without indiscriminate selective feeding of the feedstuff. The pelleting predicted the adequate utilization of the rice bran by the growing WAD goat through weight gain and no deterioration health effect on the animal fed. The observed feed conversion efficiency and increased CP level with increased rice bran shows that pelleting technique will be better employed when feeding feedstuff of lesser palatability to goats.

RECOMMENDATION

The ration did not show any negative impact on the goat's development. It is therefore recommended that further inclusion level of rice bran above 35% inclusion level in pelleted dried cassava peel should be carried out to establish an acceptable limit for growing WAD goat performance.

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Poultry Disease Control Among Rural Small Holder Poultry Farmers In Four Selected Villages In Kwara State, Nigeria

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ABSTRACT

Poultry production in the rural areas is faced with a number of constraints such as high prevalence of poultry diseases, inadequate supply of vaccines and medicines which on the long run result in low productivity and reduced profitability. This study examined poultry disease control among rural small holder poultry farmers. A total of 240 respondents were interviewed, and of these, 59.4% were female and 40.6% were male. The highest source of livelihood was 41%, poultry keeping accounts for 12%. The most observable symptoms of disease outbreak were bloody, greenish and whitish diarrhea (30.2%), coughing and sneezing was 14.9%, while nasal discharge took 11.4%. Swelling of head, comb and eyes was18.1%, 25.4% was reported for the twisting of head and neck. 60.2% of the respondents depend on the existence and usage of traditional medicines to treat outbreak and prevent spread of disease. A shift from the traditional ways of treating poultry diseases to use of vaccines and medicines will increase productivity and profitability.

INTRODUCTION

The early poultry production was rudimentary and characterized by small number of birds per household, usually kept for special occasions (Chaiban, 2021). None of such household poultry production units can be described as a commercial entity. Small-scale poultry production systems are mostly found in rural, resource-poor areas that often also experience food insecurity (Kelvin *et al*., 2021), such rudimentary rural production still accounts for over 90% of chickens produced in many developing countries (Mujyambere *et al.*, 2022). The extensive poultry production system is the most commonly found in rural areas, and usually involves indigenous chicken genotypes. Poultry production in the rural areas is faced with a number of constraints which on the long run result in low productivity and reduced profitability. Productivity of village chicken is low and is hampered by problems of feed shortage, low chick survival rate, transportation, weather change, poor extension services, high prevalence of poultry diseases, inadequate supply of vaccines and medicines and lack of good housing management (Ola-Fadunsin *et al*., 2019). Village chicken production is dominated by indigenous chickens that exhibit remarkable adaptation to local environment; rural poultry production plays a vital role in the growing economy of the rural populace. It provides livelihood security to households in addition to securing the availability of food (Andrette *et al*., 2021). However, Disease outbreak is a major concern in rural poultry production and has a negative effect on production. Hence, efforts are therefore needed from all rural poultry farmers for prompt and active treatment of chicken geared towards improving the rate of production of egg and meat of village chicken.

MATERIALS AND METHODS

Four villages from Kwara South Senatorial District were randomly selected with sixty (60) respondents per village, a total of two hundred and forty (240) respondents were used for this study and the names of the four villages selected are Edidi, Isanlu-Isin, Etan and Ajuba. Data were collected by a trained enumerator that could translate the structured questionnaires into local language for low level illiteracy respondents. Due to poor internet availability in the selected areas paper questionnaires were used. The data collected included household characteristics, source of livelihood, observable symptoms during disease outbreak and steps taken to prevent the spread of diseases. Data collected from the respondents were collated and analyzed for most frequently selected answers by the small holder poultry farmers. Frequencies and percentages were reported.

RESULTS AND DISCUSSION

Table 1: Distribution of households' heads and other household characteristics

Gender of household heads	Percentage	Frequency
Male	61.9	148.56
Female	38.1	91.44
Gender of respondents in the household		
Male	40.6	97.44
Female	59.4	142.56
Age of household head		
20-29	1.9	4.56
30-39	9.7	23.28
40-49	13.5	32.40
50-59	29.9	71.76
60-69	29.7	71.72
70+	15.4	35.96
Education of household head		
None	37.0	88.80
Primary	25.4	60.96
Secondary	26.4	63.36
Tertiary	11.2	26.88
Relationship of survey respondent with household head		
Household head	61.1	146.64
Spouse	35.5	85.20
Other family members	3.4	8.16
Other non-family members	0.0	0.0

The household head is chiefly accountable for the cultural, social, nutritional and economic well-being of the household, the study showed that the male household head is higher than the female, men as household heads in the rural areas relative to women are at an advantaged position in the accessibility of society's economic resources and privileges. Men have easier access to lands due to paternal inheritance than women in Nigeria. Women who are household heads may be more independent and have more control over resources by virtue of their position than women who are not household heads (Saleemi and Kofol, 2020). As expected, most of the interviewed respondents were women (59.4 percent of women and 40.6 percent of men) this shows that women could be more involving than men in poultry keeping. The percentage of the age of household heads range of 50- 59 is similar to that of 60-69 an indication of economic empowerment age range of catering for the household members. The level of education of household head is a vital personal quality to make firm and strong decision on challenges of poultry production, 37% of the household heads were illiterate. Higher literacy level of household heads enhances the ability for information usage which will improve application of the knowledge to challenging situation of any poultry disease outbreak and combating the outbreak with the right treatment which will increase production, profitability and thus improve the nutritional status of the households (Chota *et al*., 2021).

Table 2: Distribution of households by source of livelihood

	Percentage	Frequency
Crop farming	41	98.4
Sheep/goat farming	7	16.8
Poultry keeping	12	28.8
Livestock product trading	0	0.0
Trading in non-livestock products	5	12
Formal salaried employment	9	21.6
Self-employed – trade	12	28.8
Self-employed- services	12	28.8
Fisherman	0	0.0
Old/retired	1	2.4
Others	1	2.4

The highest source of livelihood in the selected community is crop farming as shown in Table 2, which was 41% compare with other sources of livelihood this is in consonance with Okon *et al*., (2021), that reported that crop farming takes approximately 94% of Nigeria's agricultural sector. However, poultry keeping accounts for 12% this could be due to the challenge of disease outbreak of poultry production in the rural community (Herrero-Encinas *et al*., 2021). The village chickens are really vaccinated against poultry diseases; hence during the period of outbreak, the keepers are at the risk of losing the birds to the outbreak. The frequency for self- employed either in trade or in services were similar this due be due to advantages accrued to self-employment where the owner determine the schedule and control the work environment.

Table 3: Distribution of symptoms observed during disease outbreak among flock

	Percentage	Frequency
Diarrhea	30.2	72.48
Bloody, green & white		
Coughing & sneezing	14.9	35.76
Nasal discharges	11.4	27.36
Swelling	18.1	43.44
Head, comb& eyes		

Twisting Head & neck	25.4	60.96
Others	0.0	0.0

Poor protective resistance against diseases, unavailability of veterinary workers and low production are among several factors that challenge the future growth of the poultry industry (Hafez and Attia, 2020). The appearance of poultry feaces provides lots of information about the health or general wellbeing status of chickens. Bloody, greenish and whitish diarrhea was the most observable symptoms of disease outbreak (30.2%) among the poultry farmers. Diarrhea is characterized by the passage of frequent and soft or watery faeces, it is also known as watery bowel movements (Rivero-Perez *et al*., 2019). Diarrhea is a sign of many diseases in poultry and can be as a result of parasitic, bacterial, fungal, and viral infections. A whitish, chalky paste seen in the poultry's fecal droppings could be due to pullorum disease is a disease of poultry caused by the bacterium *Salmonella pullorum* of which mortality rate can reach 100% if the problem is not treated on time (Borda-Molina *et al*., 2018), whitish diarrhea is among the symptoms of infectious bursal disease. The clinical symptoms of coccidiosis include bloody diarrhea. Newcastle disease can cause greenish feaces in chickens, furthermore, fowl cholera is a disease caused by a bacterium called *Pasteurella multocida* which can also cause greenish faeces in chickens. Coughing and sneezing was 14.9%, while nasal discharge took 11.4%. Different ages of chickens and be infected and come down with signs of listless, sneezing, coughing and nasal discharge. Swelling of head, comb and eyes was18.1%, infectious coryza is a known acute respiratory disease of chickens characterized by reduced activity, sneezing, nasal discharge and facial swelling. Twisting of head and neck sign may be due to infectious, non-infectious and nutritional causes. 25.4% is reported for the twisting of head and neck. Newcastle disease is one of the most important and worldwide manifestation signs for torticollis.

Table 4: Distribution of steps taken to control the spread of diseases

	Percentage	Frequency
Treated by self with modern medicine	26.8	64.32
Treated by self with traditional medicine	60.2	144.48
Treated by veterinary practitioner	1.3	3.12
Slaughtered, process and consumed	4.3	10.32
Slaughtered, processed and gifted	3.1	7.44
Culled and sold the bird	4.3	10.32

60.2% of the respondents depend on the existence and usage of traditional medicines to treat the outbreak and prevent spread of disease. This could be due to high cost of conventional medicines and vaccines coupled with the lack of knowledge on their uses, these drugs are usually out of reach of the small-scale farmers. Treatment of poultry diseases may a burden to the rural household economy (Rist et al., 2015).

CONCLUSION

Good protective resistance against diseases such as the usage of vaccines, medicines and availability of veterinary workers should be adopted by rural poultry farmer for increased profitability.

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Hormonal Profile In Male And Female Poultry During The Wet And Dry Seasons.

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INTRODUCTION

Background of the study

Poultry refers to a group of birds of particular species that are domesticated and raised for the production of eggs (chickens, guinea fowl, duck, quail, and geese), meat (chicken, turkey, quail, duck, and guinea fowl), and other uses like feathers (ostriches, peacocks), leather (ostriches), as pets (pigeons), as guardians (geese) (pigeons). Their production is one of the livestock production with significant contribution to human food (Sibhatu and Qaim, 2018). The hormonal balance in the body affects their growth, development and reproduction, the release of these hormones are used to mark the developmental stage of puberty and the entrance into the age of maturity in animals. This reproductive hormones released have many roles, it operates in the body using the negative feedback system, part of its function is that it induces the development of the reproductive organs and controls other secondary development into maturity, these are responsible for the sexual and reproductive behaviour leading to reproduction. The hormones include **testosterone, progesterone, follicle stimulating hormone, Luteinizing hormone, prolactin** and **oestrogen**, these hormones are all working interdependently, each affecting the other to cause stimulation of chemicals in the body.

Leutinising Hormone (LH)

Leutinizing Hormone (LH), a glycoprotein that controls gonad activity, is another gonadotrophic hormone generated in the pituitary gland by gonadotroph cells. It controls how well the ovaries and tesetes work. In men, it stimulates the laydig cells in the testes to produce and secrete testosterone, while in females, it stimulates the interna cells and lutal cells of the ovaries to produce oestrogen and progesterone, respectively. Luteinizing hormone concentrations rise during the female ovulation phase along with progesterone release and corpora lutea development. Gonadotroph Releasing Hormone (GnRH) secretions control the release of Luteinizing Hormone (LH).

Prolactin (PRL)

Prolactin is produced from the lactotroph cells in the anterior pituitary gland. This hormone has shown some degree of gonadal function in domestic animals and rodents. The brooding behaviors in birds and the metabolic changes during that period of brooding is as a result of the increased concentrations of prolactin in birds. Hypothalamus produces several neuro hormones that regulates the secretion of prolactin, this in turn affects prolactin concentrations. Among the neuro hormones secreted by the hypothalamus dopamine (or prolactin inhibitory hormone (PRL-IH)) is the most important because it inhibits the action of prolactin synthesis (Rastrelli et al., 2015).

Oestrogen

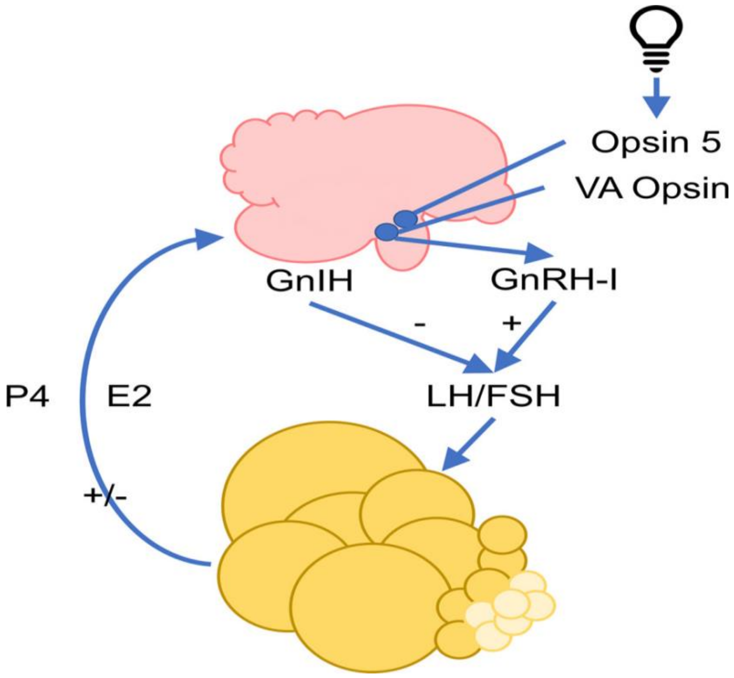
Oestrogen is a steroid hormone produced in the granulosa cells of the ovaries, it is also produced in males in the sertoli cells of the testes. This hormone is one of the main factors of reproductive development, is stimulates maturation and follicular growth, prepare the genitalia for copulation, induce Oestrus behaviour (heat) in females to help in mating processes, provide beneficial conditions to the development of fertilized egg cells, prepare the uterus for parturition and influences the growth of the mammary gland in mammals. Oestrogen have many roles on the influence of the female reproductive organs during maturation.

Progesterone (P_4)

The luteal cell in the ovaries produces the steroid hormone progesterone, which regulates body development and causes the female body to mature. The foundation molecule for it is a cholesterol molecule produced by the placenta and corpus luteum. This hormone gets the uterus ready to receive oozytes that have been fertilized. It inhibits female reproductive behaviour associated with oestrus. In the vagina, it causes exfoliation and secretion of mucus membrane. In the cervix it causes a blockage and closure by forming a mucous plug to prevent any infiltration into the uterus.

Testosterone

The male hormone known as testosterone, which is likewise a steroid hormone and is generated in the leydig cells of the testes, is responsible for spermatogenesis. The testicular tissue maintains a high concentration of testosterone, which is transported throughout the body through diffusion from the spermatic cord to the testicular arteries and veins. Testosterone has roles in spermatogenesis promotion, anabolic growth, and accessory sex gland secretion promotion. A negative feedback loop that occurs at different levels of the male sex hormone system controls the male sex hormones. (Gillies and McArthur, 2010).

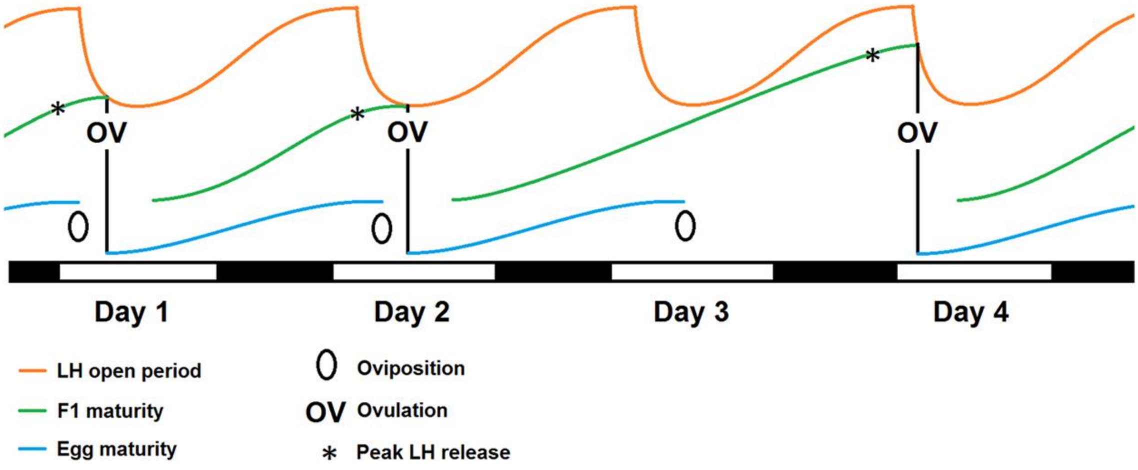


Effect of Season on Poultry Production

Changes in the weather variations affect the production of poultry birds and thus it is important to know and determine the effect that they have on the production of the birds so as to counter their adverse effects. In agricultural production, weather and climate changes are the most variable inputs affecting production, day by day it is managed. The main climatic factors affecting poultry reproduction are temperature and humidity (Nawab et al., 2018). In Nigeria most poultry farmers practice a low level or no level of technological input in their operation and management, it is mostly an extensive or semi-intensive system of management and if not, a dip-litter integrated system for most commercial poultry farmers (Heise et al., 2015).

Effect of Lighting schedule

With seasonal changes in the environment the behaviour and habits of the birds change slightly, like for instance how the increase or decrease in daylight affect the egg production, egg production in poultry is greatly affected and stimulated by daylight and length of day (Olanrewaju et al., 2010) this means that the longer the day the increase in production. Fig 2 shows how the photoperiod affects the release of hormones and thus reproductive development. As the season changes the length of day and night slightly changes, in the summer months (April-July) the length of day is longer while in the winter months (October-January) the length of day is shorter (Bradshaw and Holzapfel, 2007to 30 percent (van der Klein et al., 2020), this is done to ensure efficient and constant maximization of egg production.



Effect on the Reproductive Performance

As a result of seasonal fluctuation the production performance is decreased as well as significant decrease in egg weight, egg shell thickness and eggshell weight (Ahaotu., et al. 2019).

The dry season

This period is characterized with low amounts of rainfall, increase in solar radiation as a result of low cloud cover and low humidity. The dry season in Nigeria is divided into two main seasons: The Hot-dry season and The Harmattan. The major characteristic of dry season in the tropic regions such as Nigeria is dry heat and more windy conditions in the arid areas of the northern Nigerian areas, it is between the months of March to May. The harmattan is a season between the months of November and February, this period is accompanied by low temperatures, dusty-windy conditions and dryness.

Heat Stress

When chickens struggle to maintain a balance between the heat generated internally by the body and the heat lost to the environment, a condition known as heat stress results. (Igbokwe et al. 2018) The term "thermo neutral zone" refers to the range of ambient temperatures where an animal's normal productive and maintenance functions can be carried out without discomfort, balancing the heat lost to the environment without necessitating a higher rate of metabolic heat production.

The Reproductive hormones and Ovulation

Oestrogen and Progesterone are the two main hormones inducing the sexual maturity and reproduction in female animals. Ovulation, sexual maturity, and oviduct development are all influenced by estrogen. The pituitary gland responds to progesterone by releasing the hormones luteinizing hormone (LH) and folicle stimulating hormone (FSH), which start the formation of the yolk. Testosterone and Progesterone stimulates albumen formation (Lucas and Ostagno, 2013). Heat stress (acute and chronic) causes reduction in progesterone and testosterone levels because the increase in temperature causes a decrease in the concentration of ascorbic acid which is necessary for their synthesis. This in turn affects the concentration of Letuinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) (Rozenboim et al., 2007).

Folliculogenesis

As a result of heat stress, the stimulation of Follicle Stimulating Hormone (FSH) is disrupted and the concentration of oestrogen, progesterone and testosterone are decreased. In mature hens, only the left ovary releases eggs, as the time of egg laying period approaches the ovary is activated and the follicles are released, because of the alteration of the normal stimulation and concentration of the reproductive hormones a few amount of follicles are stimulated and even still they do not grow well. (Igbokwe et al., 2018)

Ovulation

A sexually matured hen begin to ovulate when the yolk is released from a matured follicle, the initiation of ovulation is due to neurological and hormonal factors. Because of heat stress this initiation is delayed because the concentration of the reproductive hormone is decreased and the number of matured follicle is reduced. The next ovulation which is triggered by the egg lay is affected too because of the delay of egg lay (Rozenboim et al., 2007).

The Wet Season

This period, also called rainy season in Nigeria is mainly characterized by heavy rainfall it is mostly between the month of June to October. During this period there is high humidity as a result of frequent rainfall and as there increased cloud cover there is reduced intensity of solar radiation. The length of day is longer than the dry season meaning an increased rate of egg laying activities, also the feed intake will be more and the water intake will be lesser during this period. Because the overall environmental condition during the wet season is to a cooler temperature, the activity of the birds will be increased.

Management of Seasonal changes

In Nigeria, the effect of change in weather and season can be managed by taking proper measures though various techniques and methods such as the construction of the housing, the feeding and diet of the birds, the stocking density of birds and even the type of birds are all considered in determining the means of proper management of seasonal effect on poultry birds.

CONCLUSION

In poultry production, the reproductive-hormonal axis is more balanced during the wet season, the profile of the hormones are normal and this in turn favors reproduction thus, the reproductive performance of both male and female poultry is much better during the wet season. Poultry production in the tropics is more favourable during the wet season. At dry season, heat stress causes the rate of production to plummet and the quality of eggs and chicks is low this is because of the disruption of the hormone. Seeing this fact, poultry birds fare better during the wet season where the ambient temperature is cooler. Farmers should take measures to maintain comfort for the birds during the dry season and prevent heat stress, being that this alters the behaviour and production of the birds. With the knowledge of the effects of the seasons on the reproductive hormonal profile specific measures can be taken with target towards the balance and maintenance of these hormones in both the wet and dry season.

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Sensory Evaluation Of Broiler Chickens Fed Diets Containing Fermented Cassava Leaf-Stump Mix

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ABSTRACT

An experiment to assess the sensory and organoleptics characteristic of broilers chickens fed diets containing fermented cassava leaf- stump mix (FCLS) meal as replacements for maize. The cassava leaf and stump were fermented in solid state using Aspergillus niger ATCC 16404 for 96 and 192 hours respectively at room temperature. FCLS meal was prepared by mixing the fermented cassava stump and fermented cassava leaf at ratio of 19:1. The birds were allotted into four treatments with three replicates (n= 30). Treatment 1 contain 0% FCLS, while treatments 2 to 4 contain 20%, 40% and 60% FCLS meal respectively. There was a significant difference ($P < 0.05$) in the flavor, tenderness and texture. The overall acceptability was statistically similar ($p > 0.05$), however, the highest acceptability was obtained in Diet 3 (containing 40% FCLM). Therefore, inclusion of FCLS up to 60% inclusion level is acceptable to the consumers and may not have any negative effect on the palatability of broiler chicken meat.

Keywords: Cassava stump, Cassava leaf, Solid state fermentation, palatability, *Aspergillus niger*

INTRODUCTION

Broiler chicken has tremendous capacity to develop faster than any other meat sources (Kralik et al., 2018). The meat also has high quality nutrients, ease of preparation and delicious taste. The poultry feed industry is currently facing challenges of volatility in the cost of production due to soaring bills of conventional feedstuffs; thus, the search for alternative feed ingredients.

The by-products of cassava tuber are some of the alternatives being assessed by livestock scientists as a replacement for maize. However, these by-products as individual are low in crude protein and have high crude fiber (Latif and Müller, 2015). Leaf meals are known to be good sources of protein but the use is limited by the anti- nutrients and high fiber components. Morgan and Choct (2016) advocated fungal solid-state fermentation (SSF) as a veritable way of improving the nutritional quality of cassava by- products. Khempaka et al. (2014) observed increased level of protein of cassava and its by-products through fermentation by yeast. Sugiharto et al. (2019) also reported the use of enzymes and fermentation to solve the challenges of high fibre and anti – nutrient factors thereby enhancing the availability of the bioactive compound in the leaf meals.

The assessment of the quality of meat is vital, as it is view in relation to the quality of the meat component and the palatability factors. It is also a measurement of duration of meat freshness before deterioration commences (El Masry et al., 2012). The hydrogen index and nutrient composition affect the sensory/organoleptic traits of meat (Jayasena et al., 2013).

The study was therefore undertaken to determine the effect of feeding fermented cassava leaf-stump mix meal as replacements for maize on the sensory/organoleptics characteristics of broiler chickens.

MATERIALS AND METHODS

Experimental location: The experiment was conducted at the Poultry Unit of the Landmark University Research Farm, Omu Aran, Irepodun local Government, Kwara State, Nigeria. Coordinates 8°08′00″N5°06′00″E

Sources of materials: Cassava leaf and stumps were obtained from the Cassava processing Unit of Landmark University, Omu Aran while other feed ingredients were purchased from Ilorin, Kwara State.

Fermentation procedure: The dried cassava leaves and cassava stump were inoculated with *Aspergillus niger* (ATCC 16404) aseptically and fermented under room temperature for 96 hours and 192 hours for cassava leaf and stump respectively using the method described by Aro and Akinjokun (2012). The fermented cassava leaf and stump were then mix at the ratio of 1:19 to form the leaf-stump mix meal.

Proximate Components: The proximate analysis of the unfermented and fermented cassava leaf-stump mix meal were carried out using the method of AOAC, 2006.

Management of birds: Day old Ross broiler chicks were allocated based on their initial weight into four dietary treatments of 30 chicks per group, and 10 chicks per replicates. All vaccination and medication schedule, and standard management practices were adhered to. Portable water and feed were provided without restriction for the period of 56 days experimental period.

Experimental diets and design: FCLS mix meal was prepared by mixing the fermented cassava stump with fermented cassava leaf at ratio 19:1. Four experimental diets each were made for the starter and the finisher phases. The Diet 1 contained no FCLS, while treatments 2, 3 and 4 had maize replaced by 20, 40 and 60% FFCS. The diets' compositions are presented in table 2.

Sensory evaluation: Ten semi-professional panelists were selected for this evaluation using boiled meat samples from the breast muscle. Samples were rinsed, put in a clear double nylon bags and labeled. These were then cooked until tissue internal temperature reached 75^{o}C. The cooled boiled meat was thereafter given to the panelists. Each panelist chewed one sample per treatment and scored for appearance, taste, aroma, flavor, tenderness, texture and overall acceptability, using a Nine-Point Hedonic scale ranking.

Statistical analysis: All data produced were subjected to a One-Way Statistical Analysis of Variance (ANOVA) using SAS (2009). Duncan's New Multiple Range Test based on significant level of $P < 0.05$ was then used to evaluate the significance differences among the treatments.

RESULTS AND DISCUSSION

The Tables 1 and 2 show the proximate composition of the unfermented and fermented cassava leaf–stump mix meal and the diets composition respectively. The result of the sensory evaluation of the broiler meat is shown in Tables 3.

Proximate Analysis: The results showed that the SSF using Aspergillus niger 16404 enhanced the nutritive values of cassava leaf–stump mix meal, this is agreement with Olukomaiya et al. (2019) and Shi et al. (2021).

The organoleptic/sensory evaluation

The appearance, aroma, taste and overall acceptability values were not influenced ($P > 0.05$ by FCLS (table 3); Semjon et al. (2020) reported similar observation when broiler rations where supplemented with solid state fermented feed. This signifies that the inclusion of the FFCS in the diets did not hamper the sensory organoleptic characteristics of the broiler meat. Higher numerical values for aroma and tenderness were observed in the control diet. Melton (1990) has earlier posited that diets type affect the aroma of meat. Mottram (1991) also observed that meat aroma trait is because of complex interaction of precursors derived from both the lean and fat compositions of meat generating volatile flavor compounds during cooking. The better overall acceptance of the meat from chickens fed FFCS containing diets in this study is also in accord with that of Abu et al. (2015).

CONCLUSION

From this study, it can be deduced that solid state fermented FCLS can serve as a good energy resource in broiler production. For optimal result, up to 40% of FCLS mix meal could be incorporated in to the diet of broiler chickens with no fear of any detrimental consequence on the organoleptic indices. Further study may be carried out on the cassava stump using bacteria and other fungi or consortium of microorganisms to see if better result can be obtained.

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Table 1 Proximate composition of unfermented and fermented cassava by-products

Parameters (%)	UCLS	FCLS
Moisture	11.80	7.33
Crude protein (CP)	3.77	8.81
Ether extract (EE)	5.82	8.79
Crude fiber (CF)	10.27	7.59
Ash	3.32	6.90
Nitrogen free extract (NFE)	64.82	60.58

UCLS = Unfermented cassava leaf-stump mix; FCLS = Fermented cassava leaf-stump mix

Table 2: Composition (%) of broiler diets (on dry matter basis)

INGREDIENTS	STARTER PHASE				FINISHER PHASE			
(%)	DIET 1	DIET 2	DIET 3	DIET 4	DIET 1	DIET 2	DIET 3	DIET 4
Maize	56.00	44.80	33.60	22.40	65.00	52.00	39.00	26.00
FCLS	0.00	11.20	22.40	33.60	0.00	13.00	26.00	39.00
SBM	38.01	38.01	38.01	38.01	30.00	30.00	30.00	30.00
Fish meal	2.00	2.00	2.00	2.00	1.20	1.20	1.20	1.20
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.10	0.10	0.10	0.10
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Cal. Analysis								

CP (%)	23.90	23/81	23.73	23.64	20.72	20.56	20.40	20.24
ME (kcal/kg)	3036	2970	3016	3005	3073	3057	3044	3030

FCLS = Fermented cassava leaf-stump mix; SBM = Soyabean meal; CP = Crude protein; ME = Metabolizable energy; Cal. Analysis – Calculated analysis; Diet 1 = Control diet without Fermented cassava leaf-stump mix; Diet 2 = Diet containing 20% Fermented cassava leaf-stump mix; Diet 3 = Diet containing 40% Fermented cassava leaf-stump mix; Diet 4 = Diet containing 60% Fermented cassava leaf-stump mix.

Table 3: Sensory Evaluation of chicken meat from the broiler chickens fed diets containing the Fermented cassava leaf-stump mix

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	± SEM
Appearance	7.63	7.71	7.52	7.70	1.23
Aroma	7.76	7.50	7.63	7.56	1.20
Taste	7.80	7.75	8.00	7.60	0.85
Flavour	7.76^{a}	7.91^{a}	7.91^{a}	6.14^{b}	0.25
Tenderness	8.28^{a}	7.75^{b}	7.88^{ab}	8.00^{a}	0.10
Texture	8.25^{a}	7.88^{b}	6.50^{c}	8.38^{a}	1.20
Overall Acceptability	7.63	7.63	8.13	7.25	0.15

a, b, c, d = Means on the same row but with different superscript differ significantly (P > 0.05)
SEM = Standard error of mean; Diet 1 = Control diet without Fermented cassava leaf-stump mix; Diet 2 = Diet containing 20% Fermented cassava leaf-stump mix; Diet 3 = Diet containing 40% Fermented cassava leaf-stump mix; Diet 4 = Diet containing 60% Fermented cassava leaf-stump mix.

Performance Of Broiler Finisher Fed Sweet Potatoes Peel Meal As Energy Source

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ABSTRACT

A four-week feeding trial was conducted to determine the effect of Sweet potatoes peel meal (SPPM) on the growth performance of broiler finishers chicks. To achieve this, three hundred (375) four-week old broiler finisher chicks were randomly allocated to five experimental diets in a completely randomized design (CRD). Each treatment was replicated three times having twenty-five birds per pen. SPPM was prepared and fed at graded levels of 0.0, 7.5, 15.0, 22.5, and 30. The parameters measured and calculated include final weight, total weight gain, daily weight gain, total feed intake, daily feed intake, feed to gain ratio and feed cost per kilogram gain. The heamatological parameters were also measured. The results showed that dietary levels of inclusion of SPPM had significant (P<0.05) effect on these parameters. The final weight, the weight gain and feed intake of the birds fed 0,7.5% and 15.0%SPPM were statistically (P>0.05) similar and significantly (P<0.05) higher than those of other treatments. Cost of feed per birds and feed cost per kilogram gain were lower for all SPPM diets. The cost of feed decreased as the level of SPPM increased in the diet.There were no significant differences (P>0.05) between the treatment means for packed cell volume (PCV), heamoglobin (Hb) and Total protein (Tp). It was concluded that inclusion of SPPM in the diets of broiler finisher at 15% level has beneficial effects. Therefore, 15.0% level of inclusion is recommended in the diets of broiler finishers,

Keywords: Haematology**,** Performance, Sweet potatoes peel meal, broiler finisher, graded levels

INTRODUCTION

Livestock Agriculture is very important in every economy of the world, including Nigeria. Poultry farming is an essential part of the agricultural industry and plays a vital role on the national economy. In many developing countries, like Nigeria. The major constraint of poultry production has always been high cost of quality feeds. Feed cost was estimated to be about 74% of the total cost of production [1, 2]. Livestock accounts for 40% of the Gross Domestic Products (GDP) and employs 1.3 billion people while supporting the livelihoods of one billion of the world's poor [3]. Poultry products are always at short supply because the population is increasing geometrically while the poultry production is increasing arithmetically. So, there is always pressure on the products available making the available poultry products to be costly. The population was estimated at one hundred and forty million (4). This high cost has been attributed to the over-dependence on the expensive conventional feed stuffs such as maize which mainly used in poultry feed formulation as a major source of energy. This high cost of feed necessitates research into non-conventional feed stuffs (NCF) that are readily available, cheap and nutritionally safe for the consumption of poultry.Utilization of SPPM which has crude protein of about 3.45%, Dry matter of about 91.20% and Metabolizable energy of 3089.9 Kcal/kg in poultry feed may lower feed cost because they are not consumed as food by humans. Thisstudywasdesignedtoevaluatethegrowthperformanceandhaematologicalparametersof broiler starter fed graded dietary levels of sweet potatoes peel meals.

MATERIALS AND METHODS

The experiment was conducted at the poultry section Department of Livestock, Ministry of Agriculture, Mariri, in Kumbotso Local Government Area of Kano State. Five experimental diets of SPPM at 0.7.5, 15.0, 22.5 and 30.0% levels for T1, T2, T3, T4 and T5 were formulated respectively. The feed composition for the chicks is shown in Table 1. The birds were randomly assigned to pens in a completely randomized design (CRD). There were five treatments and three replications of the five treatments each with 25 birds per pen. The management of the birds was carried out according to the standard procedures for brooding, vaccination and medication. The birds and feeds were weighed weekly. The performance characteristics were measured in terms of total weight gain, daily weight gain, total feed intake, daily feed intake, and feed to gain ratio. Haematological samples were collected into a sterile,

Table1: Gross composition of Broiler finisher diets containing SPPM

Ingredients (%)	0	7.5	15.0	22.5	30.0
Maize	56.55	50.70	47.55	43.90	40.90
Groundnut cake	23.50	21.85	17.50	13.65	9.60
Sweet potatoes peel meal	0.00	7.50	15.00	22.50	30.0
Soybean meal	8.00	8.00	8.00	8.00	8.00
Maize offal	5.00	5.00	5.00	5.00	5.00
Fishmeal	2.00	2.00	2.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Limestone	1.00	1.00	1.00	1.00	1.00
Common salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.10	0.10	0.10	0.10	0.10
*Vitamin/trace min. premix	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis (%)					
ME (kcal/kg)	3010	3025	3030	3035	3045
Crude Protein	21.00	21.00	21.00	23.00	23.00
Methionine	0.62	0.62	0.62	0.62	0.62
Crude fibre	3.40	4.56	6.25	7.43	7.50.
Ether Extract	6.80	6.92	6.45	6.00	6.95
Ash	6.40	6.45	6.45	6.42	6.15
Calcium	1.21	1.23	1.12	1.19	1.20

SPPM: Sweet Potatoes Peel Meals

RESULTS AND DISCUSSIONS

Table 2 shows the performance of broiler starter finisher fed Sweet potatoes peed meal. The final weight, total weight gain, daily weight gain and feed to gain ratio, of birds fed 0, 7.5% and 15% SPPM were similar, higher and better than those on other treatments, this could be an indication that chicks were able to efficiently utilize SPPM at 7.5% and 15% better than other levels. This result of better feed to gain ratio observed for birds fed 7.5.0 and 15% SPPM could also be due to the fact that there were sufficient metabolizable energy that were better utilized at this level.

Table 3 shows the result of the effect of SPPM in broiler diets on some haematological parameters of broiler finisher chicks There were no significant differences (P>0.05) between the treatment means for Packed cell volume (PCV), haemoglobin (Hb) and total protein (Tp).The non-significant (P>0.05)difference shown in the PCV, Hb and Tp showed that any of the diets was good enough to supply sufficient nutrients for birds.

CONCLUSION

From the results of the experiment, it was concluded that up to 7.5% of SPPM may be included in the diets of broiler chicks without any significant negative effect on growth performance.

Table2: Effects of feeding diets containing SPPM on performance of Broiler starter chicks

Measurements	0.0	7.5	15.0	22.5	30.0	SEM
Initial weight(g/bird)	1000.00	1000.00	1000.00	1000.00	1000.00	0.00
Final weight(g/bird)	2889.21^{a}	2887.60^{a}	2850.00^{b}	2730.60^{c}	2690.80^{d}	20.11
Total weight gain(g/bird)	1889.21^{a}	1887.60^{a}	1850.00^{a}	1730.60^{b}	1690.80^{c}	17.22
Daily weight gain(g/bird)	67.147^{a}	67.41^{a}	66.07^{a}	61.80^{b}	60.39^{c}	4.98
Total Feed intake(g/bird)	3370.10	3360.70	3300.90	3239.00	3223.00	32.45
Daily feed intake(g/bird)	120.36	120.60	120.28	115.96	115.68	17.20
Feed to Gain Ratio	1.78^{a}	1.78^{a}	1..78^{a}	1..87^{b}	1.90^{c}	0.15
Feed cost/Kg weight gain(₦)	145.70^{e}	134.05^{d}	120.75^{c}	110.22^{b}	105.60^{a}	4.88

^{abcd}Meanswithinthesamerowwithdifferentsuperscriptsdiffersignificantly (P<0.05)

Table 3: Effects of SPPM based diets on some blood parameters of broiler finisher chicks

Parameters	0.0	7.5	15.0	22.5	30.0	SEM
PCV (%)	29.57	33.56	32.55	31.53	31.50	1.45
Hb(g/d1)	9.82	11.60	11.50	11.42	11.23	0.84
TP(g/d1)	8.43	3.42	3.30	3.30	2.30	0.53

PCV=packed cell volume, Hb=haemoglobin, Tp=Total protein, SEM=standard error of means

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Growth Performance And Survival Rate Of *Clarias Gariepinus* Fingerlings Fed *Leucaena Leucocephala* Leaf Meal-Based Diets

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ABSTRACT
The potential use of white lead tree (Leucaena leucocephala Lam.) leaf meal to replace soyabean meal in diets for Clarias gariepinus (Burchell, 1822) fingerlings was assessed in a feeding trial. A total of 150 fingerlings (mean initial weight = 6.35±0.02 g) were randomly assigned to fifteen plastic bowls. Five iso-nitrogenous diets were formulated by replacing 25% (Diet 2), 50% (Diet 3), 75% (Diet 4) and 100% (Diet 5) of soyabean meal by white lead tree leaf meal. The diet without soyabean meal replacement served as control treatment (Diet 1). The fingerlings were fed the experimental diets for 56 days. Results revealed that fingerlings fed with Diet 2 exhibited the highest mean weight gain (MWG) (15.62±0.01 g) and specific growth rate (SGR) (2.21±0.22 %/day) followed by Diets 1 and 3. There was significant difference ($p < 0.05$) in SGR values among fingerlings fed with Diets 1, 2 and 3. Fingerlings fed with Diets 5 showed lower MWG (9.88±0.02 g) and SGR (0.80±0.02 %/day) values than those fed with the other diets. Results of this present study indicate that white lead tree leaf meal could replace soyabean meal up to 25% in diets for Clarias gariepinus fingerlings.

Keywords: White lead tree leaf meal, soyabean replacement, *Clarias gariepinus*

INTRODUCTION
Fish feed plays a major role in aquaculture viability and profitability, because it accounts for at least 40 - 60% of the total production cost (Eyo, 2001; Agbugui *et al*., 2011). The major nutrients in fish feeds are protein and carbohydrate. However, conventional feedstuffs for animal feed

formulation are dwindling in supply and their prices very high (Tiamiyu *et al*., 2015). Non-conventional feed resources (NCFRs) are non-competitive in terms of human consumption, very cheap to get, readily available in large quantities (Nandeesha *et al*., 1991; Gabriel *et al*., 2007; Agbugui *et a*l., 2010) and may constitute nuisance as waste. The search for suitable NCFRs had focused on agricultural by-products of agro-processing industries (Hoffman *et al*., 1997; Madu *et al*., 2003). One of such plant resources is white lead tree, *Leucacena leucocephala*.

L. leucocephala is one of the fastest-growing trees in arid and semi-arid areas. It is a long-lived perennial legume tree. It is a multipurpose tree, valuable for its wood, which is used to make good quality charcoal, small furniture and paper pulps. Its young shoots, young leaves and seeds may be used as vegetable in human nutrition. Seeds can also be used as a substitute or as piece of jewellery (Brewbaker, 1987). In this context, the formulation of fish feed using a cheap, locally available and highly nutritious terrestrial resource such as *L. leucocephala* leaf meals is needed because the percentage crude protein is more than 20 percent. Crude protein levels of *L. leucocephala* seeds and leaf meals are comparable to high protein-containing seeds and legumes such as soybeans and cowpea; while lipid content of *Leucacena leucocephala* leaf meal is comparable to sunflower, soyabeans and cotton seeds (Srbinoska *et al.*, 2012). *Leucaena leucocephala* leaves also show high potential to be incorporated in fish feed due to their high protein content especially lysine (Kim, 2012).

African mud catfish (*Clarias gariepinus*) is a common cultured fish species in Nigeria and sub-Sarahra Africa (Olaifa and Bello, 2011). The species is widely accepted by fish farmers and consumers because of its high growth rate, high and very efficient feed conversion ratio, excellent adaptation to ambient climate and environmental stress, disease resistance and ability to adapt to intensive culture, ease of artificial propagation, acceptance of relatively cheap feeds, high fecundity, unquestionable market demand and high customers’ acceptance (Huisman and Richter, 1987; Fagbenro *et al.*, 1999). The experiment is designed to determine the growth performance and survival rate of *C. gariepinus* fingerlings fed with varying percentages of white lead tree (*Leucacena leucocephala*) leaf meal-based diets reared in plastic bowls.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Feed mill unit of the Federal College of Freshwater Fisheries Technology (FCFFT) New Bussa, Niger State, Nigeria.Latitude 9° 53″N and Longitude 4° 33" E.

Experimental Fish

Live one hundred and fifty (150) *Clarias gariepinus* fingerlings of average weight of 2.83±0.02 g were purchased from A and B fish farm, Koro, New Bussa, Niger State. They were transported to the experimental site. The experimental fish were acclimatized to experimental condition in a plastic bowl in the College Feed mill for 3 days in the bowls during which they were fed on 40% crude protein Blue Crown feed before the commencement of the experiment.

Feed Preparation

The white lead tree (*Leucaena leucocephala*) leaves was harvested within the premises of Federal College of Freshwater Fisheries Technology, New Bussa. The other ingredients used to formulate the experimental diets which include soyabean, groundnut cake, fish meal, yellow maize and the fixed ingredients (vitamin and mineral premix, vegetable oil, methionine, lysine, DCP and salt) were purchased from local markets in New Bussa (Table 1). The ingredients were separately processed and milled to a fine powder form using 2 mm diameter dice in the flat die pelletizer of 40 - 60 kg/hr capacity and then sun-dried for 12hours. The milled ingredients were kept in air tight containers until required.

Experimental Design

Soyabean (SBM) was replaced with white lead tree leaf meal (WLLM) at 0% (DT1), 25% (DT2), 50% (DT3), 75% (DT4) and 100% (DT5) respectively. The formulation was done using the Pearson square method. The WLLM based diets were randomly allocated to triplicate 10fish/bowl in a completely randomised design (CRD) for 56 days. The fish were weighed with an electronic sensitive weighing balance (OHAUS-LS-200 model). The plastic bowls (30L capacity) were washed, thoroughly rinsed and filled with water to 16cm high.

RESULTS AND DISCUSSION

The results of proximate analysis of white lead tree (*Leucaena leucocephala*) leaf meal (WLLM) are presented in Table 1.

Table 1: Proximate analysis of white lead tree (*Leucaena leucocephala*) leaf meal

Parameter	Percentage dry weight
Moisture content	6.43
Crude protein	23.85
Crude fat	7.68
Crude fibre	8.70
Crude ash	5.13
NFE	48.55

Nitrogen Free Extract (NFE) is calculated by difference = 100 – (protein + lipid + fibre + ash)

The Percentage composition of the experimental diets is presented in Table 2.

Table 2: Percentage composition of the experimental diets (dry matter basis)

	White lead tree leaf meal inclusion levels (%)				
Feed ingredients (%)	**0**	**25**	**50**	**75**	**100**
WLLM	0.00	11.88	23.75	35.63	47.50
Soyabean meal	47.50	35.63	23.75	11.88	0.00
Groundnut cake	47.50	47.50	47.50	47.50	47.50
Yellow maize	1.00	1.00	1.00	1.00	1.00
Vitamin premix	1.00	1.00	1.00	1.00	1.00
Vegetable oil	1.00	1.00	1.00	1.00	1.00
Methionine	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
Bone meal	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

WLLM = White lead tree leaf meal

The proximate composition of the white lead tree leaf meal-based diets is presented in Table 3.

Table 3: Proximate composition (%) of white lead tree leaf meal-based diets

Parameters	DT 1 (0%WLLM)	DT 2 (25% WLLM)	DT 3 (50% WLLM)	DT 4 (75% WLLM)	DT 5 (100%WLLM)
Moisture content (%)	9.85	7.31	8.06	8.12	7.97
Crude protein (%)	40.65	40.81	39.25	39.02	39.00
Crude fat (%)	5.05	3.97	4.74	4.61	4.47
Crude fibre (%)	3.97	4.97	4.84	5.05	5.37
Crude ash (%)	4.97	4.84	5.05	5.37	5.70
NFE	35.31	36.65	36.65	35.91	35.15

Values with the same superscripts across the rows are not significantly different (p<0.05)

The result is similar to others, Sotolu and Faturoti, (2009), Mary *et al.* (2010) and Falaye *et al.* (2016).

The growth performance and survival rate of *C. gariepinus* fed white lead tree leaf meal based diets are presented in Table 4.

Table 4: Growth performance and survival rate of *C. gariepinus* fed white lead tree leaf meal based diets

Parameters	DT 1 (0%WLLM)	DT 2 (25% WLLM)	DT 3 (50% WLLM)	DT 4 (75% WLLM)	DT 5 (100%WLLM)
Mean Initial weight (g)	6.32 ± 0.03^a	6.36 ± 0.01^a	6.38 ± 0.02^a	6.36 ± 0.02^a	6.32 ± 0.02^a
Mean Final weight (g)	26.88 ± 2.00^a	21.98 ± 1.00^b	17.56 ± 1.00^c	11.97 ± 0.20^d	9.88 ± 0.34^e
Mean weight gain (g)	20.56 ± 2.00^a	15.62 ± 0.95^b	11.18 ± 0.94^c	5.61 ± 0.20^d	1.56 ± 0.32^e
Specific growth rate	2.59 ± 0.12^a	2.21 ± 0.22^b	1.81 ± 0.09^c	1.13 ± 0.12^d	0.80 ± 0.05^e
Total feed intake (g)	16.30 ± 2.11	10.56 ± 1.00	7.77 ± 1.12	4.65 ± 1.12	2.10 ± 0.40
Food conversion ratio	0.79 ± 0.10^e	0.68 ± 0.12^d	0.69 ± 0.05^c	0.83 ± 0.06^b	1.35 ± 0.06^a
Survival rate (%)	97.78^a	84.44^b	77.33^c	75.55^c	66.67^d
Culture period (days)	56	56	56	56	56

Mean values in the same row with different superscripts are significantly different (p < 0.05)

It was revealed that fish fed with control (Diet 1) gave the best results in terms of growth and survival rates. Fish fed diets containing 25% white lead tree leaf meal along with 75% soyabean meal were observed to have the better result among the treatments, with final weight gain of 21.98 g, specific growth rate of 2.21%/day and food conversion ratio (FCR) of 0.68±0.12; these results were closed to the control diets. The survival rate of control diet (Diet 1) was 97.78% which was significantly different from that of the Diet 2. The result is in line with those of other workers such as Falaye *et al* (1998), Nawwar *et al* (2017) for *Oreochromis niloticus* fries fed *Leucaena luecocephala* leaf meal-based diets. However, this is contrary to the result obtained by Oladele *et al.* (2010) who recorded the best performance in *Clarias gariepinus* fed tigernut at 100% substitution of maize meal with tigernut meal.

CONCLUSION

Partial inclusion of the plant meal might have significant effect on the growth of the fish and reduction of feeding cost in an aquaculture farm. The outcomes of this study are useful in better understanding of the production of new alternative solution for soyabean meal replacement. White lead tree leaf meal could partially replace soyabean meal up to 25% inclusion level in the diet of *C. gariepinus* fingerlings without compromising growth, nutrient utilization and health. This is therefore an added advantage to fish farmers providing a cheap alternative to substitute for soyabean meal.

RECOMMENDATION

The use of *L. leucocephala* meal in diets for *C. gariepinus* fingerlings should be considered as potential protein ingredient regardless of the anti-nutritional effect.

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Nutrient Composition Of Some Cartilaginous Fishes From Lagos Lagoon And Its Coast

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ABSTRACT

Fish is an important source of food all over the world and the assessment of the proximate composition of fish is vital. In this study, investigations were made on the nutritive composition of five cartilaginous fish species (Raja miraletus, Dasyatis magarita, Rhinobatos albomaculatus, Sphyrna couardi, Squalus megalops) from Lagos lagoon and its coast. The analysis of the nutritive composition was done using the methods of the association of analytical chemists and was revealed that Raja miraletus had the highest value of crude protein content of 25.85% while Squalus megalops has the least value of 24.83%. The carbohydrate content was highest in Squalus megalops (4.88 %) with the least value of carbohydrate evident in Dasyatis magarita (4.19%). The proportion of moisture content (66.17%) was highest in Rhinobatos albomaculatus while the least moisture content (61.94%) was found in Raja miraletus. The highest ether extract value (3.08%) was found in Sphyrna couardi while the least was found in Dasyatis magarita (1.69%). The highest ash content value (2.35%) was seen in Sphyrna couardi while the least value (0.36%) was seen in Raja miraletus. The crude fiber content value (4.76%) was highest in Raja miraletus while Sphyrna couardi had the least value of 1.78%. There was significant difference ($p<0.05$) in the nutritive value obtained for these fishes. However, the fishes belong to the high protein – low fat category and can be recommended in human diets to prevent protein deficiencies and excessive consumption of saturated fats.

Keywords: Proximate composition, Raja miraletus, Dasyatis magarita, Rhinobatos albomaculatus, Sphyrna couardi, Squalus megalops.

INTRODUCTION

Fish is a vital source of food which contributes to human health and digestible due to the long muscle fibres it contains (Kaur,Chugh &Gupta 2012) .It is a protein of animal origin that is found available to many Nigerians with an estimated annual per capita fish consumption of 13.3 kg in 2013 (Food and Agricultural Organisation FAO, 2017). It contains some significant amount of fatty acids ,amino acids and some major vitamins which provides energy for healthy life and at times called rich food that is available for the poor (Balami ,Sharma &Karn,2019;Bezbaruah &Deka,2021) . Fish contains four basic ingredients in varying proportions: water, protein, fat, and minerals. Flesh from healthy fish contains 60–84% water, 15– 24% protein, and 0.1–22% fat, mineral usually constitutes 1–2% (Clucas &Ward, 1996). The consumption of fish assists in maintaining a healthy status and prevent ailments such as blood pressure, cancer and coronary heart disease because of the amino acids, omega-3 highly unsaturated fatty acids (HUFA), eicosapentaenoic (EPA), docosahexaenoic (DHA) acids it is made up of (Abraha *et al*., 2018)

Proximate composition generally comprises the estimation of moisture, protein, fat and ash contents of the fresh fish body. The percentage composition of these constituent's accounts for about 96-98% of the total tissue constituents in fish (Nowsad, 2007). The chemical composition of fish flesh is regarded as a dependable predictor of the quality ,Physiological state ,habitat and nutritional value of the fish (Ravichandran, Kumaravel &Florence,2011). It is important to provide data on the proximate composition of fish since it serves as one of the major protein sources in human nutrition (Mohanty *et al.*, 2014). The Chondrichthyes are cartilaginous fishes represented by sharks, skates, and rays and most primitive living jawed aquatic vertebrates (Bouchaala ,Bouali,Ali, Benmiled , Gargouri & Fendri 2015). They are not as abundant and available as bony fishes and the available ones can be a good source of protein for human consumption (Last &Stevens ,1994). This study aims at evaluating the proximate composition and nutritive value of five cartilaginous fishes from Lagos lagoon and its coast.

MATERIALS AND METHODS

Study Area

The Lagos Lagoon is one of the several lagoons in West Africa, a brackish coastal lagoon, which lies within latitude 6° 26'–6° 37' N and longitude 3° 23'-4° 20' E and it stretches for 257km from the Benin Republic to the West and Niger Delta to the East and consists of nine lagoons namely, Badagry, Ologe, Yewa, Iyagbe, Lagos, Kuramo ,Mahin, Lekki and Epe Lagoon. Lagos Lagoon empties into the Atlantic Ocean through Lagos harbour (Nwankwo, 2004 ; Isebor, Awosika &Smith ,2006)

Fish sample collection

The cartilaginous fish species were collected based on the species available from three commercial landing sites namely Makoko fish market, Liverpool fish market, and Ijora fish market all in Lagos, Southwest Nigeria. The sampling was done during the rainy season. A total of 54 fish samples were obtained during this period which consisted of five different species of cartilaginous fishes. The species were *Dasyatis margarita* (sting ray), *Raja miraletus* (brown ray), Squalus *megalops* (dogfish shark), *Sphyrna couardi* (hammer head shark) and *Rhinobatos albomaculatus* (White spotted guitar fish). The fish species were collected randomly to represent the population. The fish samples were labelled for easy identification and kept in the freezer at a temperature of -20^{o}C prior to analysis.

Morphometric measurement

The fish specimen was removed from the freezer and thawed. Standard and Total length measurements were recorded using a measuring board and the weight taken using a weighing scale.

Proximate analysis

The proximate composition of the fish samples was done using the procedure of AOAC (1995). This method was used to evaluate the crude protein, ash, ether extract, crude fibre and moisture content of the samples.

Statistical analysis
Data obtained were analyzed using one way analysis of variance test (ANOVA) and the Duncan multiple range test was used to separate the means value using the statistical analysis system package (SAS,2005)

RESULT AND DISCUSSION

Table 1 shows the morphometric measurement of five cartilaginous fish species from Lagos lagoon and off its coast. The total length of *Raja miraletus* ranged from 12.1 cm – 43.4 cm, disc length ranged from 6.0 cm- 21.6cm and the weight ranged from 50g - 400g. The total length for *Dasyatis margarita* ranged from 38cm – 86.5cm, disc length ranged from 13.5cm -27.7 cm and the weight ranged from 101.7g -876g. For *Rhinobatos albomaculatus* , the total length ranged from 64.5cm - 64.8cm, disc length ranged from 24.4cm – 24.7cm while the weight ranged from 900g -1000g.the total length for *Sphyrna couardi* ranged from 48cm -59.5 cm, the standard length ranged from 47.5cm – 58cm while the weight ranged from 610g -1000g.The range of the total length for squalus megalops ranged from 33.5cm – 85.3cm, standard length ranged from 32.4cm- 84.5cm while the weight ranged from 100g - 3200g. The proximate composition for the five cartilaginous fishes and the SEM are given in Table 2. *Raja miraletus* had the highest protein content (25.85%) among the five cartilaginous fishes examined in this study while *Rhinobatos albomaculatus* had the least protein content (24.33%). *Squalus megalops* had the highest carbohydrate content (4.88%) with *Rhinobatos albomaculatus* having the least carbohydrate content (3.92%). For ether extract *Sphyrna couardi* had the highest value of 3.08% with *Rhinobatos albomaculatus* having the least value of 1.45%.*Sphyrna couardi* had the highest ash content of 2.35% amongst the five fish species with *Raja miraletus* having the least value of 0.36%. The crude fibre content was highest in *Raja miraletus* (4.76%) while *Sphyrna couardi* had the least value of 1.78%.The highest moisture content was found in *Rhinobatos albomaculatus* (66.17%) and the least moisture content was found in *Raja miraletus* with the value of 61.94% . Fish are usually categorized as lean, moderately fat, and fat according to its fat content, which is less than 5 percent, from 5 to 10 percent, and greater than 10 percent, respectively (Dean, 1990). Fishes are normally grouped as lean (< 5 percent), moderately fat (5 -10 percent), and fat (> 10 percent) depending on the fat contained in it (Dean, 1990) and according to Kari, Ahmad and Ayub (2022) , the standard proximate composition of fish protein is between 15-23%. The cartilaginous fishes examined in this study belong to the high protein (24-26%) –low-fat category (<5%) and based on fat content according to Dean (1990), they can be classified as lean fish. Emmanuel, Oshionebo and Aladetohun (2011), reported that *Clarias gariepinus* and *Tarpon atlanticus* belonged to the high protein -low-fat category which is in line with the protein–fat content range of the fishes used in this study. Their high protein content may be due to the high protein content in the fishes' diet The carbohydrate content in this study was found to be less than 5% and is in agreement with the carbohydrate values (1.48-4.54%) which is less than 5% obtained by Babalola, *et al.*, (2011) for five commercial fish species (*Trachurus trachurus, Sardinella aurita*, *Micropoonias furniereri, Scomber scombrus*, *Clarias gariepinus*) in Nigeria. Moisture content values of fishes obtained in this study (61.93- 66.17%) were lower than the values obtained by Olagunju, Muhammed, Mada, Mohammed and Mahmout (2012) which was (65- 74.9%) on the nutrient composition of *Tilapia* *zilli*, *Hemisynodontis membranacea*, *Clupea herengus* and *Scomber scombrus*. The observed range of ash content (0.36-2.35%) is higher than the ones obtained by Olagunju Muhammed, Mada, Mohammed &Mahmout (2012). This indicates that these fish species are good sources of mineral content.

Table 1: Morphometric measurement of five cartilaginous fish species from Lagos lagoon and off its coast

Fish species	Weight (g)	Total length (cm)	Standard length (cm)	Disc length (cm)
Raja miraletus	50-400	12.1-43.4	-	6.0-21.6
Dasyatis margarita	101.7-876	38-86.5	-	13.5-27.7
Sphyrna couardi	610-1000	48-59.5	47.5-58	-
Squalus megalops	610-1000	48-59.5	32.4-84.5	-
Rhinobatos albomaculatus	900-1000	64.5-64.8	-	24.4-24.7

Table 2. Proximate composition of five cartilaginous fishes from Lagos lagoon and its coast

FISH SPECIE	CHO	CP	EE	MOI	ASH	CF
Raja miraletus	4.75^{b}	25.85^{a}	2.34^{b}	61.94^{e}	0.36^{c}	4.76^{a}
Dasyatis magarita	4.19^{d}	25.13^{b}	1.69^{d}	64.36^{d}	1.17^{b}	4.10^{b}
Sphyrna couardi	4.64^{c}	25.13^{b}	3 .08^{a}	63.06^{d}	2.35^{a}	1.78^{d}
Squalus megalops	4.88^{a}	24.33^{d}	1.75^{c}	64.75^{b}	1.56^{b}	2.71^{c}
Rhinobatos albomaculatus	3.92e	24.83c	1.45e	66.17a	1.29b	2.34cd
SEM	0.10	0.13	0.16	0.39	0.19	0.39

Means on the same column with different superscripts are significantly different ($p< 0.05$) from each other. SEM – Standard error of means, CHO- carbohydrate -crude protein, EE-ether extract, MOI- moisture, CF- crude fibre.

CONCLUSION

The marine fish species examined in this study revealed high protein, low-fat content, and a good source of ash content and can be recommended as a rich source of nutrients in the human diet. These fish species can be used in human diets to avoid excessive consumption of saturated fats and help prevent protein deficiencies.

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Comparative Dietary Effect of Moringa, Ginger, Garlic and their Mixture on Growth Performance and Nutrient Utilization of the African Catfish, *Clarias gariepinus* Fingerlings

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ABSTRACT

A growth study was carried out to investigate the effects of dietary moringa leaf meal, ginger, garlic powder and their mixture on growth performance and nutrient utilization of Clarias gariepinus fingerlings. In a 70-day feeding trial, C. gariepinus fingerlings (N = 300; 6.90 ± 0.31 g initial weight) were fed with a basal diet (control diet CT; free of moringa, ginger and garlic); treatment "A" (2% moringa); treatment "B" (2% ginger); treatment "C" (2% garlic) and treatment "D" (2% mixture of moringa, ginger and garlic). After the feeding trial, total weight gain of fish in treatment "C" were significantly higher ($p<0.05$) than those in treatment "A" and "D" but not significantly higher ($p>0.05$) than fish in treatment "CT" and "B". Specific growth rate and relative growth rate show a similar trend with weight gain. Feed conversion ratio was highest in treatment "D" and "A" and significantly different ($p<0.05$) from treatment "CT" "B" and "C". This study suggests that, 2% supplementation of ginger and garlic powder in the diet of C. gariepinus fingerlings could improve growth performance and nutrient utilization. However, 2% dietary inclusion levels each of dry moringa leaf meal and a mixture of dry moringa leaf meal, ginger and garlic powder in the diet of same fish species could reduce palatability and consequently reduce feed intake, nutrient utilization and overall growth performance of cultured fish.

Key word: Moringa, Ginger, Garlic, Catfish, Growth performance

INTRODUCTION

The use of plant products in aquaculture have been studied in different forms of extract (aqueous, ethanol and dried powder) and reported to be medicinal (Naylor *et al*., 2021). Most common are

Garlic (*Allium sativum*) and Ginger (*Zingiber officinale*) which are both perennial crops and have been a subject of considerable interest for centuries. They are natural and readily available additives which have been reported to promote various activities like anti-stress, immunostimulation, appetite stimulant, physical and mental health enhancers and growth promoters in fish (Wahab *et al.*, 2022).

Nutritional and phytochemical analyses revealed that garlic contains about 17 amino acids, 33 sulphur compounds, several enzymes, minerals and vitamins. Studies have also revealed its antiviral, antibacterial, antifungal, antioxidant, antiprotozoal and an effective immuno-stimulant, growth promoter and improves flesh quality owing to the presence of various sulphur compounds (Nyadjeu *et al.*, 2021). Ginger (*Z. officinale*), belongs to the family Zingiberaceae. It's a flowering plant whose rhizome is commonly used as spice and flavouring agent (Britannica, 2022). Ginger is medicinal and considered a safe herbal treatment for common cold, flu and nasal congestion. It contains compound such as alkaloids, flavonoids, polyphenols, saponin, steroids, tannin, fiber, carbohydrate, vitamins, carotenoids, minerals, natural antioxidants as gingerols, shogaols and zingerone (Nyadjeu *et al.*, 2021). Moringa (*Moringa oleifera*) is also proven to be medicinal. Its leaf contains crude protein with about 26g/100g of leaf, of which about 87% is true protein (Adel and Majid, 2021). Essential amino acids found in raw moringa leaf are methionine, cysteine, typtophan and lysine which is similar in composition with those found in soybean (Ya''ara *et al.*, 2022). Although it has been reported in previous studies that moringa, ginger or garlic have been found to strengthen immunity and uplift health status, enhance growth and flesh quality in freshwater fish like carp (C*yprinus carpio*), tilapia (*Oreochromis niloticus*) and the African catfish (*Clarias gariepinus*) (Naylor *et al.*, 2021). Studies in respect to their efficacy and combined effect in the diet of the African catfish are inadequate. Thus, the aim of this study was to evaluate the effect of dry moringa leaf meal, ginger powder, garlic powder and their mixture as feed additive on growth criteria and nutrient utilization of the African catfish *Clarias gariepinus* fingerlings.

MATERIALS AND METHOD

The study was carried out from February to April, 2022 at the hatchery wet-laboratory unit of the Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos Nigeria.

Processing of Additives

Freshly harvested moringa leaves (*Moringa oleifera*), ginger roots (*Zingiber officinale*) and garlic bulbs (*Allium sativum*) were washed under a running clean tap water and wiped with a clean kitchen towel. Garlic and ginger were individually peeled to remove fore-skin before being diced with a kitchen knife. Additives were sundried for a period of 72hours, then milled to powder using a laboratory milling machine (Model: HK - 860) and sieved with a hand sieve to obtain 2kg each of the powders which were then stored in an airtight cellophane bag and refrigerated at 4^oC for further analysis.

Nutritional and Anti-nutritional Composition of Additives

The nutritional and anti-nutritional composition of all three additives were carried out based on the recommendation of the Association of Official Analytical Chemist (A. O. A. C, 2005). This includes; Nutritional (moisture contents, crude protein, crude fibre, carbohydrate, crude fat, ash and mineral content) and anti-nutritional (phytic acid, oxalate content and tannin content).

Experimental Diets and Acclimatization of experimental fish

Five iso-nitrogenous diets were formulated to contain 35% crude protein with each additive powder added at 2g/100g. Diet "A" (2% dry moringa leaf meal inclusion), Diet "B" (2% dry ginger powder inclusion), Diet "C" (2% dry garlic powder inclusion), Diet "D" (mixture of all three additives: 2% inclusion) and Diet "CT" (0% additives).

Three hundred (300) catfish juveniles of average weight of 6.7 ± 0.4g were sourced from the fish hatchery unit of the Nigerian Institute for Oceanography and Marine Research for the experiment.

Experimental Design

They were distributed in an equal number of 20 pieces into a fifteen 80L plastic tanks. Each treatment was replicated thrice in a completely randomized design and fed thrice daily at 5% body weight between (10:00h, 13:00h and 16:00h). The feeding trial was carried out for a period of 10 weeks during which the corresponding weight of fish was recorded on a biweekly basis. The experiment was conducted in a water recirculatory system (WRS) plastic tank with a water exchange rate of 70L flow per minute.

At the end of the feeding trial, the weight gain, mean weight gain, total weight gain, relative growth rate (RGR), specific growth rate (SGR) and feed conversion ratio (FCR) were estimated from fortnightly measurements.

STATISTICAL ANALYSIS

All data resulting from the experiment were presented as means ± SD and analyzed by one way analysis of variance (ANOVA) using the SPSS (statistical Package Computer, Software 2004 version Chicago Illinois, USA). Duncan's multiple range tests was deployed to compare differences among individual means. Differences were regarded as significant at $P < 0.05$ (Zar, 1999).

RESULTS AND DISCUSSION

In this study, percentage proximate composition, anti-nutritional factor, growth performance and nutrient utilization indices of *Clarias gariepinus* fingerlings fed five different diets are shown in Table 1, 2, 3 and 4.

Results of proximate composition are presented in Table 1.

Table 1: Percentage Proximate composition of Moringa leaf, Ginger and Garlic

PARAMETER	Moringa Leaf	Ginger	Garlic
Moisture %	7.8	10.6	9
Crude Protein %	25.0	10.26	18.58

Crude Fat %	4.64	4.64	0.54
Fibre %	2.97	2.97	0.88
Ash %	9.5	9.5	4.33
CHO %	50.12	50.12	66.67

Mineral composition

Results of mineral composition is presented in Table 2.

Table 2: Mineral composition of Moringa leaf, Ginger and Garlic

PARAMETER	Moringa Leaf	Ginger	Garlic
Calcium Mg/100g	110.43	158.32	67.81
Magnesium Mg/100g	185.01	181.91	97.55
Potassium Mg/100g	855.96	707.87	784.3
Sodium Mg/100g	235.1	171.12	208.9
Manganese Mg/100g	1.02	22.99	0.6
Iron Mg/100g	9.9	17.14	3.52
Copper Mg/100g	0.77	2.15	0.67
Zinc Mg/100g	1.44	2.01	1.68
Phosphorus Mg/100g	175.46	162.29	282.57

Results of anti-nutritional factors are presented in Table 3.

Table 3: Anti-Nutritional Factor Analysis of Moringa leaf, Ginger and Garlic

PARAMETER	Moringa Leaf	Ginger	Garlic
Phytic Acid g/kg	0.031	0.025	0.054
Tannins mgTAE/kg	48.73	50.28	56.15
Oxalate Mg/100g	1.97	3.28	4.17

Growth Performance and Nutrient Utilization of Experimental Fish

In this study, the growth performance and nutrient utilization indices as well as bi-weekly growth curve of *Clarias gariepinus* fingerlings fed dry moringa leaf meal, ginger and garlic powder basal diets are presented in Table 4.

Table 4: Growth Performance and Nutrient Utilization of Experimental Fishes

Parameters	CT	A	B	C	D
Initial Weight of Fish/tank (g)	128.7	133.7	132	130	138
No Stocked	20	20	20	20	20
Total Weight of Feed/tank (g)	992.41	635.67	1019.88	1010.71	552.93

Final weight of Fish/tank (g)	481.6	222	477.4	511.2	171
Weight Gain of Fish/tank (g)	352.96 ± 28.3^b	88.61 ± 21.3^a	345.4 ± 134^b	381.6 ± 71^b	32.8 ± 26.8^a
FCR	2.8 ± 0.14^a	7.2 ± 1.54^b	3 ± 0.84^a	2.7 ± 0.39^a	8.2 ± 0.63^b
SGR	0.819 ± 1.33^b	0.315 ± 0.62^a	0.798 ± 0.25^b	0.849 ± 1.72^b	0.133 ± 0.41^c
RGR	2.742 ± 1.52^b	0.66 ± 0.37^a	2.617 ± 1.95^b	2.932 ± 0.23^c	0.239 ± 1.03^a

Treatment A = Fish fed moringa leaf-based diet; Treatment B = Fish fed ginger-based diet; Treatment C = Fish fed garlic-based diet; Treatment D = Fish fed combination of moringa, ginger and garlic-based diet; Treatment CT = Fish fed Control-based diet. Values are mean ± standard deviation of three replicates of 20 fish each. Mean within the same row with different superscripts are significantly different from each other at $p < 0.05$. FCR, feed conversion ratio; SGR, Specific growth rate; RGR, Relative growth rate.

Growth performance indices reveal that, cultured fish in treatment “D” had the lowest total weight gain (32.8 ± 26.8g) while fish in treatment “C” had the highest total weight gain (381.6 ± 71g). SGR and RGR were both highest in treatment “C” with values of 0.849 ± 1.72 and 2.932 ± 0.23 respectively. These values are significantly different ($p<0.05$) from other treatments.
FCR values of *C. gariepinus* fed with different dietary inclusions of moringa, ginger and garlic basal diets are presented in Table 4. It was noted that feed consumption translated in flesh increase for most of the treatments. In general, fish fed on diet “C”, “B” and “CT” each containing 2% of garlic, ginger and control diet inclusion had the best FCR with values of 2.7 ± 0.39, 3 ± 0.84 and 2.8 ± 0.14 respectively and are significantly different ($p < 0.05$) when compared to treatments “A” and “D”. Results obtained from fish fed ginger based diet is in agreement with that reported by Oh *et al*., (2022), who reported that the incorporation of Ginger (*Z. officinale*) residue from juice extraction improves juvenile black rockfish (*Sebastes schlegelii*) growth performance, antioxidant enzyme activity, and resistance to *Streptococcus iniae* infection. Chepkirui *et al.*, (2022) also reported that, the incorporation of garlic in diets for growing Nile tilapia significantly improved weight gain and specific growth rate. Elton *et al.* (2021) also reported a significant increase in weight gain, feed efficiency, protein efficiency ratio and specific growth rate of Nile tilapia fed diet containing 3% garlic powder. The findings of this study revealed that *C. gariepinus* fingerlings fed basal diet supplemented with ginger powder or garlic powder showed better growth and feed utilization in term of weight gain, feed conversion ratio, specific growth rate as well as relative growth rate when compared to fish fed diet containing moringa or combination of dry moringa leaf meal, ginger powder and garlic powder.

In this study however, group of fish fed 2% moringa leaf meal based diet “A” and group of fish fed 2 % mixture of dry moringa leaf meal, ginger and garlic powder based diet “D” revealed that the final body weight and weight gain were significantly ($p < 0.05$) lower resulting in a reduced average daily weight gain, specific growth rate and a high feed conversion ratio as observed in

Table 4. Feeding rate of affected fish reduced and consequently a reduction in weight gain. This observation may suggests a high dose of moringa in the experimental fish diet which may reduce palatability of diet and consequently reduced feed intake. This observation is similar to the findings of Dongmeza *et al.* (2006) who reported a considerable reduction in feed intake, nutrient utilization, and growth performance of *Oreochromis mykiss* when fed with dietary *Moringa oleifera* leaf extracts. The findings of this study are also similar to the report of Puycha *et al.*, (2017) who worked on effect of moringa (*Moringa oleifera*) leaf supplementation on growth performance and feed utilization of Bocourti's catfish (*Pangasius bocourti*) and reported that dietary moringa leaf could be included in the Bocourti's catfish diet at possibly not over 10g/kg fish without a negative effect on the growth, feed utilization, digestibility and serum biochemistry. In conclusion, this study showed that dietary supplementation of ginger and garlic powder in the diet of *Clarias gariepinus* fingerlings at 2% inclusion level could improve growth performance and nutrient utilization. The study also demonstrated that, 2% dietary inclusion level of dry moringa leaf meal and a mixture of dry moringa leaf meal, ginger and garlic powder in the diet of *Clarias gariepinus* fingerlings reduces feed palatability and overall growth performance.

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Length-Weight Relationship and Condition Factor of Giant African River Prawn (*Macrobrachium Vollenhovenii*) Culture in Pond and Tank.

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ABSTRACT

Length-weight relationship and condition factor of 500 specimens of the Giant African River Prawn (Macrobrachium vollenhovenii) were cultured for 120 days in two different culture systems, 300 specimen were cultured in the pond and 200 specimens were cultured in the tank in the present study. Regression lines differed among the culture systems. The "b values" for the two culture systems were 2.415 and 2.651 respectively. The morphometric analysis revealed negative allometric growth patterns at $p < 0.05$. The parameters "a" and "b" of the morphometric analysis were estimated using the formular $W = aL^b$ while the condition factor were calculated from the equation $K = 100WL^{-3}$. The mean "K" value for the pond and tank culture systems were 0.7813 ± 0.254 and 0.8015 ± 0.475 respectively. There is no significance difference in the mean condition factor for the pond and tank culture at $p > 0.05$. Hence, further studies are required on the aspect of the water quality management of the two culture systems, which could also be a factor that must have contributed to their growth

Keywords: Length-weight Relationship, condition factor, Giant African River Prawn, Tank, Pond.

INTRODUCTION

The freshwater prawns of the genus Macrobrachium consist of over two hundred species that are distributed throughout the world, especially in the tropical and subtropical regions (Jimoh et al., 2011) vollenhovenii and macrobrachion are particularly of high economic importance in the diversification of both aquaculture and artisanal fisheries in the West African region (Bello-Olusoji, (2004).

Macrobrachium vollenhovenii which are found in both brackish and fresh waters environments in West African as a suitable choice for aquaculture in Nigeria due to its large size (Bello-Olusoji, 2004). However, its post larvae and brood stocks were usually obtained from the wild due to the constraints of getting hatchery-raised prawns (Anetekhai et al., 2007). Since, morphometric parameters such as length and weight were generally used as criteria for selecting brood stocks. It is therefore essential to ascertain the well-being of the brood stocks and post-larvae before been raised for consumption. Hence, knowledge about their growth pattern and state of health is important.

Length-weight relationship has vital importance in fisheries science. It helps in establishing mathematical relationship between the two variables, enabling conversion of one variable to the other (Le Cren, 1951), to describe growth in the wild (Enin, 1994; Abohweyere and Williams, 2008; Deekae and Abowee, 2010), to determine possible differences among different stocks of the same species (Petrakis and Stergiou, 1995; King, 2007), delineate the stocks and comparative growth studies (Sampaio and Valenti, 1996; Primavera et al., 1998; Peixoto et al., 2004). Although shrimp body weight is commonly recorded for culture management purposes (e.g. estimations of growth rate, feed conversion ratio, harvest weight, and productivity), the application of morphometric relationships could be a simple alternative to estimate body weight from length measurements that are less variable and more easily measured in the field (Cheng and Chen, 1990; Primavera et al., 1998).

Most recent works on the length-weight relationship and condition factor of Macrobrachium species includes Lagos lagoon (Abohweyere and Wilhams, 2008; Abohweyere, 2008b), Cross River estuary, Nigeria (Enin, 1994), Bello Olusoji (2005) on species from Rivers, Osun, Ogun and Osse. Yakub and Ansa (2007) used Length-Weight relationship as a tool to assess the general wellbeing of the pink shrimps- Penaeus notialis and giant tiger shrimps- P. monodon of Buguma creek in the Niger Delta. The observed condition factor suggested the ecological suitability of the brackish water of Buguma creek to be suitable for co-habitation of indigenous pink shrimp and exotic giant shrimp.

A study on the Length-weight relationship of M. vollenhovenii in Asejire Lake provides base line data for management decision on the species in the area and similar water bodies. The information on growth- length-weight relationship forms the basis for estimating mortality, recruitment and other parameters of populations.

MATERIALS AND METHOD

Area of Collection: juveniles of M. vollenhovenii were collected from Ogun River at Isheri Olofin area of Okunmanya River in Ogun State. They were caught with mosquito net trap.

Acclimatization: the prawns were transported in 50-liter plastic containers with or without water in an air-conditioned car to Badore NIOMR out station in Lagos State. On arrival at the Station, the prawns were treated with 5-ppm formalin for disinfection before they were transferred to quarantine tanks and acclimatized to the new environment.

The study area is Nigerian Institute of Oceanography and Marine Research, Badore Station. 500 specimens of Giant African River Prawn cultured in pond (300 specimens) and tank (200 specimens) were measured. The study period was from April to August 2019 (120 days). The culture shrimps were fed with 0.8-1.2mm imported extruded COPPENS feed twice daily at 3% body weight throughout the culture period. The specimens for the length-weight relationship (LWR) were collected after harvest using scoop net.

Total length (TL) was measured to the nearest 0.1 cm using 30cm ruler from the distance of the tip of the rostrum to the tip of the telson. The body weight was measured to the nearest 0.01g using sensitive weighing balance. The (LWR) was calculated using the conventional formula $W = aL^b$ where W = body weight, L = total length in centimeters while "a" and "b" are regression constant and regression coefficient respectively (Ricker, 1973). Log transformed as log W = a + b log L, a is the intercept in y-axis and the regression coefficient b is an exponent indicating isometric growth when close to three. The ANOVA was carried out carried out using spss. The statistical significance level was estimated. The condition factor (K) of the shrimps was calculated using the K = 100 WL-3 (Pauly, 1983). Where K = condition factor, W = body weight of shrimp (g) and L = Total length of shrimp (cm). The analysis was carried out using Microsoft Excel version of 2010.

RESULTS

The values for elevation (a) and slope (b) together with their corresponding regression coefficient (r^2) for the length–weight relationships in M. vollenhovenii of the two culture systems are presented in the Table.

M. vollenhovenii cultured in tank has significantly lower value of b (Table 1), indicating lower weight gain relative to increase in length compared to the pond culture. The growth in the tank culture showed isometry where as it is positive allometry in the pond culture. Although the slope in tank culture was found higher than pond culture, no significant difference was observed between the tank and pond culture system. Scatter diagrams of length and weight for the two-culture system exhibited curvilinear relationship were shown in Figure 1 and 2 below.

Table: Regression analysis of *Macrobrahium vollenhovenii* cultured in tank and pond.

	Regression constant (a)	Regression coefficient (b)	Correlation coefficient (r)	Mean ISD	K	
					Range Min	Max
Tank	0.0140	2.4149	0.7441	0.80150± 0.475	0.4418	1.7384
Pond	0.0103	2.6514	0.8086	0.78131± 0.254	0.2348	3.0951

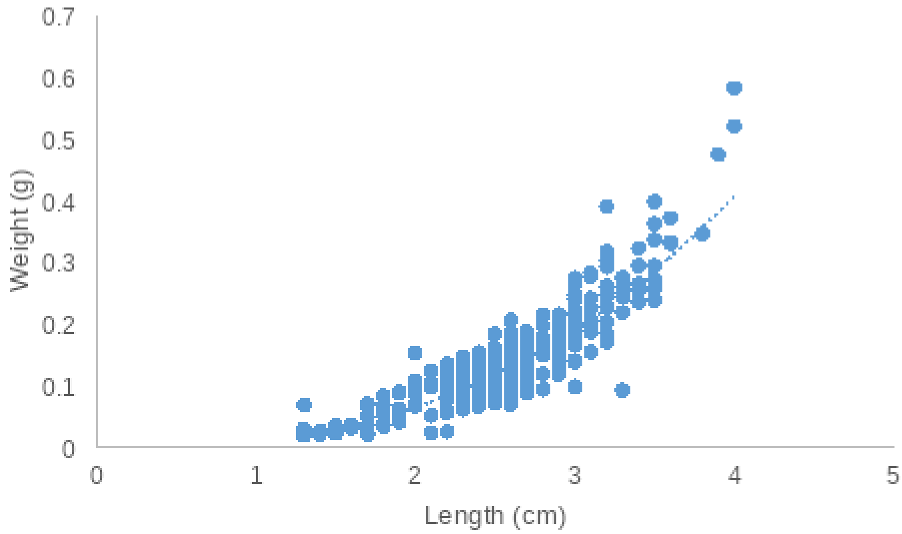

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Fig. 1: Length-weight relationship of *Macrobrahium vollehovenii* cultured in pond.

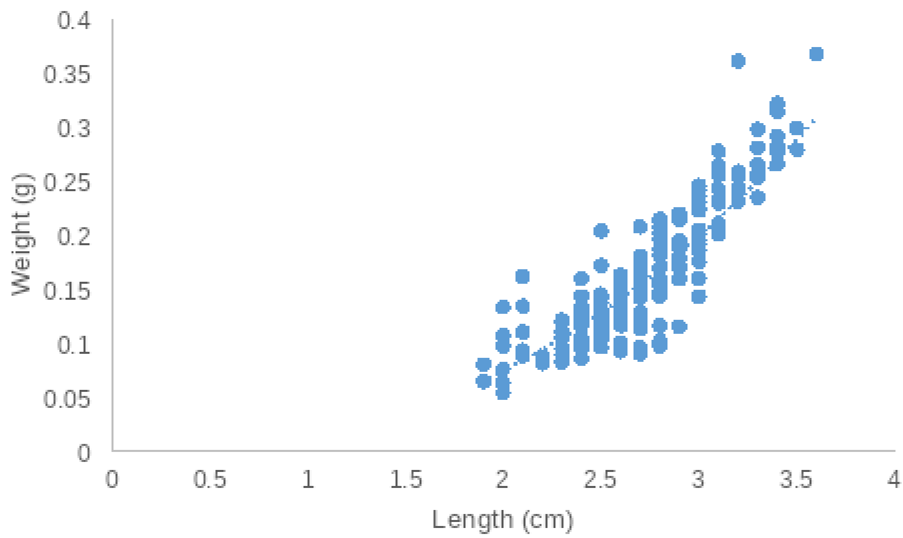

Fig. 2: Length-weight relationship of *Macrobrahium vollehovenii* cultured in tank.

The condition factor obtained in the present study show mean standard deviation, which is from 0.80± 0.47 in the tank culture to 0.78± 0.25 in the pond culture (Table 1). The table also show the ranges of the condition factor to be No significant variation was observed in K in the two culture systems with the pond culture showing the higher followed by the tank culture.

DISCUSSION

Lalrinsanga et al. (2012) reported that shellfish maintains dimensional equality; the weight increase will be proportional to the cube of length increment while the slope value less than 3 indicates that the animal becomes slender as it increases in length whereas slope greater than 3 denotes stoutness indicating allometric growth. Kunda et al. (2008) reported isometric growth (b= 3.075) of M. rosenbergii in Rice Field with coefficient of determination (r^2) of 0.99 which in contrast to the present study with negative allometric growth (b= 2.6514 and 2.4149) with coefficient of determination (r^2) of 0.88 and 0.74 which is similar to the work of Kunda et al. 2008. The values obtained indicating negative allometric growth. These values are similar to those obtained in the work of Gopalakhrishnan et al. (2013) Length-weight Relationship and Condition Factor of Wild, Grow-out and "Loose Shell Affected" Giant Tiger Shrimp, *Penaeus monodon* and Matanmi, M.A. (2014) Length-weight Relationship, Condition Factor and Sex Ratio of Black Tiger Shrimp (Penaeus monodon) Reared in NIOMR Shrimp Grow-out Concrete tank.

Information on condition factor (K) can be vital to culture system management because they provide the producer with information of the specific condition under which organisms are developing (Araneda et al., 2009). It reflects recent physical and biological circumstances, and fluctuates by interaction among feeding conditions, parasitic infections and physiological factors (Le Cren, 1951) and it is an indicator of the changes in food reserves and therefore an indicator of the general fish condition.

The K observed in the present study ranges from 0.44 to 1.73 in tank culture and 0.23 to 3.09 for the pond culture, indicating that the prawns are in good condition. Kunda et al. (2008) reported a condition factor and relative condition factor (Kn) of 1.09 and 1.00, respectively in M. rosenbergii under rice fields suggesting good condition of the prawn. P.L. Lalrinsanga et al. (2012) also reported a condition factor of 0.79 and 1.41, respectively in length-weight relationship and condition factor of giant freshwater prawn M. rosenbergii (De Man, 1879) based on developmental stages, culture stages and sex similar ranges of condition has also been reported in other species of Macrobrachium (Arimoro and Meye, 2007; Enin, 1994).

CONCLUSION

Prawn fishing in Nigeria is facing challenges of over fishing and pollution caused by industries like oil and gas, bottling industries and Nigeria breweries. Hence, the knowledge about Prawn Aquaculture, their growth pattern and state of health is important. This present study indicates that *M. vollenhovenii* cultured in tank has a higher value of condition factor with a slightly lower growth value compared to the one cultured in the pond. This can be as result of water changing in tank and availability of natural nutrient, live feeds and poor water condition in the pond. Further research work is required to be carried out on this study especially the water Quality Management aspects.

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Diet supplementation with soaked pawpaw seed meal at higher inclusion levels suppressed growth performance and feed utilization in *Clarias gariepinus* juveniles

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ABSTRACT
This eight-week fish nutritional experiment was carried out to appraise the effect of supplementing soaked pawpaw (Carica papaya) seed meal (SPSM) in the diet on growth and feed utilization of 360 Clarias gariepinus juveniles (initial mean weight = 8.5±0.37 g) inside 18 plastic aquaria (50 × 40 × 40 cm^3). SPSM was incorporated at six increasing graded levels (0, 10, 20, 30, 40 and 50%) labeled as Diet 1 (control diet), Diet 2, Diet 3, Diet 4, Diet 5 and Diet 6 respectively. The SPSM-supplemented diets (40% crude protein) and fish carcass were proximately analyzed via standard procedures. Indices such as Mean Weight Gain (MWG), Specific Growth Rate (SGR) and Feed Conversion Ratio (FCR) were assessed. Data generated were analyzed using one-way analysis of variance (ANOVA) at $P \leq 0.05$. Final carcass crude protein (62.2 – 64.5%) significantly ($p < 0.05$) superseded 56.31% in the pre-experimental fish. Juveniles fed with Diet 2 (10% SPSM supplementation) had significantly ($p < 0.05$) superior values of MWG (16.2 g), SGR (1.9%/day) and FCR (1.86). Higher SPSM supplementation (20 – 50%) caused progressively depressed pattern of growth and feed utilization indices. This study has revealed that up to 10% soaked pawpaw seed meal supplementation produced the best growth and feed utilization in C. gariepinus juveniles.
Key words: Soaked pawpaw seed meal, *Clarias gariepinus*, Survival, Proximate analysis, Protein intake

INTRODUCTION

Aquaculture development has often been regarded as an indispensable remedy to the lingering shortage of animal protein intake in developing countries which is largely due to rapid human population growth. In routine aquaculture operations, feed supply alone constitutes a major operational cost for most fish farmers as it accounts for about 40 – 70% of the total operational cost of sustainable fish farming (Dossou *et al*., 2021). The scarcity and escalating cost of most conventional feed ingredients have necessitated the use of unconventional alternative feed resources for reducing feed cost and maximizing profit from aquaculture practices. The search for such unconventional feed ingredients and evaluation of their nutritional suitability have become major determinants for improving aquaculture feed industry (Watanabe, 2002). Feed formulation based on cheap locally available domestic, agricultural and agro-industrial by-products plays a vital role in aquaculture feed industry (Tacon, 2002). Vegetable and fruit processing wastes or by-products constitute potential sources of energy and protein which should be harnessed as alternative ingredients in fish feed to reduce feed cost and thereby facilitate sustainable aquaculture (Jimenez-Yan *et al*., 2006). In addition to various reports on the nutritional relevance of legumes, oilseed cakes, cereal grains, rice bran and several other by-products as ingredients in aqua diets, vegetable and fruit wastes are equally nutritive and abundant (Daniels, 2006). There have been many useful reports regarding the use of vegetable and fruit wastes as unconventional feed ingredients in fish feed (Basker *et al*., 2011; Rebecca and Bhavan, 2011; Sajitha *et al*., 2011; Foramarzi *et al*., 2012; Bhavan *et al*., 2013).

One of such plants is pawpaw (*Carica papaya*) whose seeds have been used in various studies. Chemical analysis of pawpaw seed powder has been reported to contain 22.56 - 30.08% crude protein, 22.2 - 34.80% crude lipid, 1.67% crude fiber, 7.11 - 7.97% total ash and 23.67 - 47.27% nitrogen-free extract (Bolu *et al.*, 2009; Farrag *et al*., 2013). Several studies have been conducted on the utilization of processed pawpaw seeds in the diets of fish and other monogastric animals such as langur monkey (Lohiya *et al*., 2002), wistar rats (Naggayi *et al*., 2015), albino rats (Raji *et al*., 2005), broiler chickens (Bolu *et al*., 2009), *Oreochromis niloticus* (Farrag *et al*., 2013; Khalil *et al*., 2014) and *C. gariepinus* (Ayotunde *et al*., 2010). In view of the afore-mentioned studies, it is obvious that, regardless of available literature reports on the nutrient composition and dietary potential of pawpaw seed meal, there is still scanty information about its incorporation as a supplement in the diets for *C. gariepinus* juveniles. Therefore, this study was conducted to assess the suitability and influence of supplementing diet with graded increasing levels of soaked pawpaw seed meal on growth performance, feed utilization and survival of *C. gariepinus* juveniles.

MATERIALS AND METHODS

Formulation and preparation of experimental diets

Large quantities of ripe pawpaw (*C. papaya*) fruits were purchased from Iba market, Lagos State, Nigeria. The fruits were sliced open to extract the fresh mature seeds (6 kg) used in this study which were cleaned and soaked for 24 hours in a 20-litre plastic bucket containing clean water. The soaked seeds were removed, sieved, sufficiently sundried for 3 days to constant weight after which they were milled to a fine powder using a locally fabricated domestic food blender and kept in a dry air-tight polyethylene bag at room temperature pending its inclusion in the diets. Other ingredients were procured from a standard feed mill and ground separately into a powdery form. Six iso-nitrogenous (40% crude protein) experimental diets were formulated from various ingredients as presented in Table 1. Soaked pawpaw seed meal (SPSM) was incorporated as a supplement at increasing graded levels of 0 (control diet without SPSM), 10, 20, 30, 40 and 50% in the diets which were respectively coded as 0% SPSM (Diet 1), 10% SPSM (Diet 2), 20% SPSM (Diet 3), 30% SPSM (Diet 4), 40% SPSM (Diet 5) and 50% SPSM (Diet 6). Each diet was individually prepared by thoroughly mixing the dry ingredients inside a mixer after which groundnut oil and warm water were added to homogenize the dry mixture into a uniform paste. Each diet paste was steam-pelleted using a 2-mm die Hobart pelletizer. The resultant pellets were collected, sufficiently sundried for three days, cooled to room temperature and wrapped in separate air-tight containers prior to fish feeding.

Experimental design and fish husbandry

This eight-week feeding experiment was conducted in the fish nutrition research laboratory of the Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria. A total of 400 *C. gariepinus* juveniles were procured from a reputable commercial hatchery in Okitipupa, Ondo State. The juveniles were acclimatized to the experimental conditions inside four fiberglass tanks (1 m × 1 m× 0.5 m) for 7 days and fed twice daily with 2 mm Coppens feed. At the start of this study, 360 equal-sized fish (initial mean weight: 8.5±0.37 g) were batch-weighed on a sensitive balance and randomly allotted into 18 plastic aquaria (50 × 40 × 40 cm^3) at twenty juveniles per aquarium each containing 20 litres of borehole water. A completely randomized design was used to assign six dietary treatments in three replicates each to the fish aquaria to make up 18 treatment units. Fish were manually fed twice daily (07:00 - 08:00 and 17:00 - 18:00 hrs) at 5% of their body weight in two equal rations with constant aeration in the aquaria via air-stones connected to a central air pump. Temperature, dissolved oxygen concentration and pH of the culture water were monitored. Fish in each aquarium were batch-weighed weekly and weight gain recorded. Eight grams of each diet sample, six pre-treatment fish specimens and four post-treatment fish specimens per treatment were randomly collected, kept frozen and later used to determine the proximate composition of experimental diets and fish carcass. The proximate indices analyzed included crude protein, crude lipid, crude fibre, total ash, moisture content and nitrogen-free extract (AOAC, 2011).

Table 5: Ingredient composition of experimental diets containing soaked pawpaw seed meal (SPSM) as a supplement

Dietary ingredients	0% SPSM Diet1 Control	10% SPSM Diet 2	20% SPSM Diet 3	30% SPSM Diet 4	40% SPSM Diet 5	50% SPSM Diet 6
Soaked pawpaw seed meal	0.00	1.67	3.34	5.01	6.68	8.35
Maize meal	16.7	15.03	13.36	11.69	10.02	8.35
Fish meal	25.10	25.10	25.10	25.10	25.10	25.10
Soybean meal	25.10	25.10	25.10	25.10	25.10	25.10
Groundnut cake	25.10	25.10	25.10	25.10	25.10	25.10
Min/vitamin premix*	1.50	1.50	1.50	1.50	1.50	1.50
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00

Salt	1.00	1.00	1.00	1.00	1.00	1.00
Groundnut oil	1.00	1.00	1.00	1.00	1.00	1.00
Cassava starch	2.50	2.50	2.50	2.50	2.50	2.50
Total	100.00	100.00	100.00	100.00	100.00	100.00

SPSM: Soaked Pawpaw Seed Meal

Biological appraisal of fish growth performance and feed utilization indices

The following indices of growth and feed utilization were appraised:

i. $Mean\ weight\ gain\ (MWG) = (W_2 - W_1)\ g$

where: W_1 = initial mean weight (g); W_2 = final mean weight (g)

ii. $Percentage\ weight\ gain(\%) = \frac{Mean\ weight\ gain\ (g) \times 100}{Initial\ mean\ weight\ (g)}$ (Adesina and Agbatan, 2021)

iii. $Feed\ intake\ (g) = WFI_1 + WFI_2 + WFI_3 + WFI_4 + \ldots\ldots WFI_n$

where: WFI= weekly feed intake of fish per treatment (g);
1, 2, 3, 4,……..n= first week to the last week of the experimental duration

iv. $Feed\ conversion\ ratio\ (FCR) = \frac{Mean\ feed\ intake\ (g)}{Mean\ weight\ gain\ (g)}$ (Adesina and Agbatan, 2021)

v. $Specific\ growth\ rate(\%/\text{day}) = \frac{(\text{Ln Wf} - \text{Ln Wi}) \times 100}{t\ (days)}$ (Adesina and Agbatan, 2021)

where: Ln W_f = natural logarithm of fish final weight; Ln W_i= natural logarithm of fish initial weight; t= experimental duration in days.

vi. $Protein\ intake\ (g\ of\ protein\ in\ 100g\ diet/fish) = \frac{feed\ intake \times \%\ crude\ protein\ in\ diet}{100}$
(Adesina and Ikuyeju, 2019)

vii. $Protein\ efficiency\ ratio\ (PER) = \frac{Mean\ weight\ gain}{Mean\ protein\ intake\ (g\ of\ protein\ in\ 100g\ of\ diet/fish)}$
(Adesina and Ikuyeju, 2019)

viii. $Nitrogen\ metabolism\ (NM) = \frac{0.549 \times (Wi+Wf)t}{2}$

where: W_i= initial mean weight of fish; W_f= final mean weight of fish; t= experimental period in days; 0.549 = metabolism factor

ix. $Percentage\ survival,\ PS(\%) = \frac{Final\ number\ of\ fish\ harvested \times 100}{Initial\ number\ of\ fish\ stocked}$ (Adesina and Ikuyeju, 2019)

STATISTICAL ANALYSIS

Data obtained on the effect of supplementing diets with soaked pawpaw seed meal on proximate indices, growth, feed utilization and body composition of *C. gariepinus* juveniles were analyzed using one-way analysis of variance (ANOVA) based on the SPSS Statistics 22.0 version (IBM, USA). Differences among the six treatment groups were determined by means of Tukey's multiple range tests and were considered statistically significant at $p < 0.05$. All the data presented in this study were expressed as means of triplicate values (n = 3) ± standard deviation.

RESULTS AND DISCUSSION

Table 2 shows the proximate composition indices of the experimental diets which revealed an irregular pattern regardless of increasing levels of soaked pawpaw seed meal (SPSM) supplementation. Values of these indices conformed to the recommended range suitable to ensure ideal fish growth (Li *et al*., 2014). Crude protein values (38.94 – 41.01%) agreed with 32.35 – 40.65% earlier documented for oven-dried pawpaw seed meal and other seed meal-supplemented diets (Farrag *et al*., 2013; Bake *et al*., 2016, 2020; Michael and Mathias, 2020; Zulhisyam *et al*., 2021; Michael *et al*., 2021). Crude lipid values (5.12 – 9.99%) almost harmonized with 10 - 20% lipid in prepared fish diets which generally boosts ideal growth rate without producing unduly fatty carcass (Tibbetts and Lall, 2013). The present values tallied with 5.23 – 6.59% found in oven-dried pawpaw seed meal-supplemented diets (Farrag *et al*., 2013). Moreover, the present values of crude fibre and ash favorably complied with 10.75 – 11.12% recorded by Farrag *et al*. (2013) and 8 - 12% recommended for optimal fish growth (Condey, 2002) since higher crude fibre and ash contents usually reduce the digestibility of other dietary ingredients and cause high waste production which may lead to water pollution and poor growth. Values of nitrogen-free extract (NFE) (18.31 – 21.09%) were lower than 46.49 – 54.4% found in oven-dried pawpaw seed meal-supplemented diets (Farrag *et al*., 2013). The observed dissimilarities in the values of these proximate indices and earlier studies probably emanated from the influence of environmental factors on the seeds (Akajiaku *et al*., 2014), morphological differences in plant species, various processing techniques adopted and differences in ingredient mixtures.

Table 2: Proximate composition of graded levels of soaked pawpaw seed meal-supplemented diets fed to *C. gariepinus* juveniles

Proximate indices	0% SPSM Diet 1 Control	10% SPSM Diet 2	20% SPSM Diet 3	30% SPSM Diet 4	40% SPSM Diet 5	50% SPSM Diet 6
Crude protein (%)	40.13±0.93[a]	39.65±1.15[a]	40.38±0.78[a]	40.12±0.63[a]	41.01±0.81[a]	38.94±1.68[a]

Crude lipid (%)	6.45±0.05^{b}	9.61±0.79^{d}	8.23±0.08^{c}	7.02±0.12^{b}	5.12±0.93^{a}	9.99±0.51^{d}
Ash (%)	11.14±1.36^{a}	10.43±0.62^{a}	9.94±0.56^{a}	11.14±0.74^{a}	10.26±1.04^{a}	10.92±1.12^{a}
Crude fibre (%)	14.57±0.67^{b}	11.28±0.92^{a}	13.55±0.65^{b}	11.54±0.76^{a}	16.34±0.64^{c}	11.94±0.76^{a}
Nitrogen-free extract	18.31±0.91^{a}	20.15±1.05^{ab}	19.76±0.44^{ab}	21.09±1.41^{b}	19.24±0.94^{ab}	18.71±0.79^{a}
Moisture (%)	9.50±0.9^{a}	8.89±1.3^{a}	8.14±1.56^{a}	9.18±0.48^{a}	8.09±2.11^{a}	8.55±0.75^{a}

Mean values with different superscripts a, b, c, etc. along the same row are significantly different ($p < 0.05$). SPSM: Soaked Pawpaw Seed Meal

Table 3 presents carcass proximate composition indices of post-experimental fish. The appreciable elevation of carcass protein content in the post-fed *C. gariepinus* juveniles obviously validated enhanced protein synthesis and new tissue formation as earlier noted by Yusuf *et al*. (2016) for *C. gariepinus* juveniles. Appreciably elevated carcass crude protein values have also been reported for *C. gariepinus* fingerlings and juveniles fed variously processed seed meal-supplemented diets (Bake *et al*., 2016, 2020; Aliu and Osaro, 2018; Michael and Mathias, 2020; Jibrin *et al*., 2021; Michael *et al*., 2021; Zulhisyam *et al*., 2021). Final carcass crude lipid values (8.05 – 10.73%) displayed an irregular pattern of significant variations which possibly implied that increasing dietary inclusion levels of SPSM did not cause a corresponding increase in fat deposition in the fish. This finding, however, contradicted the progressively increasing fat accumulation detected in *O. niloticus* fingerlings fed pawpaw seed meal-supplemented diets (Farrag *et al*., 2013) and *C. gariepinus* fingerlings placed on toasted flamboyant seed meal-supplemented diets (Bake *et al*., 2016). These values superseded 1.5 – 6.68% documented by other authors (Bake *et al*., 2016, 2020; Jibrin *et al*., 2021) but fell below 13.47 – 15.12% noticed in *C. gariepinus* fingerlings fed toasted lablab bean meal (Aliu and Osaro, 2018). The dissimilarities observed in fish carcass composition between this study and other similar studies could be associated with variations in fish species' genetic make-ups, plant-based ingredients used, processing techniques adopted as well as influence of environmental factors or culture conditions.

Table 3: Carcass proximate composition of *C. gariepinus* juveniles fed graded levels of soaked pawpaw seed meal-supplemented diets

Proximate indices	Initial values	0% SPSM Diet 1 Control	10% SPSM Diet 2	20% SPSM Diet 3	30% SPSM Diet 4	40% SPSM Diet 5	50% SPSM Diet 6
Crude protein (%)	56.31±1.81^{a}	62.2±1.7^{b}	63.35±2.85^{b}	64.5±2.2^{b}	62.9±0.8^{b}	63.53±3.48^{b}	63.58±3.48^{b}
Crude lipid (%)	10.45±0.85^{ab}	8.05±0.95^{a}	10.73±0.77^{b}	8.86±1.41^{ab}	9.11±0.56^{ab}	9.65±1.75^{ab}	10.3±1.8^{ab}
Ash (%)	10.98±0.12^{a}	10.38±2.12^{a}	10.63±1.57^{a}	9.44±0.74^{a}	10.89±0.81^{a}	8.75±1.45^{a}	9.43±1.17^{a}

Nitrogen-free extract	11.75±0.45[a]	11.48±1.72[a]	9.27±2.23[a]	10.19±1.01[a]	9.24±0.79[a]	10.36±1.82[a]	10.48±1.67[a]
Moisture (%)	10.51±1.59[a]	7.94±1.66[ab]	6.04±2.06[a]	7.01±1.19[a]	7.87±0.14[ab]	7.72±0.91[a]	6.22±1.83[a]

Mean values with different superscripts a, b, c, etc. along the same row are significantly different ($p < 0.05$). SPSM: Soaked Pawpaw Seed Meal

Table 4 shows the result of growth response, feed utilization and percentage survival indices which exhibited significant ($p < 0.05$) variations in the post-experimental *C. gariepinus* juveniles. Supplementing SPSM in the diets has caused appreciable increase in feed utilization and weight gain. Acceptance of diets vis-à-vis weight gain significantly ($p < 0.05$) increased in the fish placed on Diets 1 to 2 (0% - 10% SPSM) beyond which it progressively diminished with further increase in SPSM supplementation levels. Similar findings were reported on *C. gariepinus*, *O. niloticus* and *Heterobranchus bidorsalis* fingerlings fed with related seed meal-supplemented diets (Balogun *et al*., 2004; Bake *et al*., 2016; Oyegbile *et al*., 2017). The highest mean weight gain (MWG) and specific growth rate (SGR) (16.2 g and 1.9% day^{-1} respectively) attained by fish fed Diet 2 evidently attested to their optimal diet utilization and better conversion of dietary nutrients to flesh when compared with those fed with the other diets. The significantly lower growth indices manifested by fish placed on Diets 3 to 6 could be associated with low diet intake, diminishing palatability of the diets and presence of anti-nutrients in the diets. This finding corroborates the report of Akande and Fabiyi (2010) that most anti-nutrients inactivate some important dietary nutrients by obstructing the digestive process or metabolic utilization of feed which in turn impairs optimum nutrition. Comparable reducing growth responses were observed in *O. niloticus* and *C. gariepinus* fingerlings at higher inclusion levels of pawpaw seed meal and related seed meal-supplemented diets (Farrag *et al*., 2013; Bake *et al*., 2016). The current SGR values (1.3 – 1.9 %day^{-1}) harmonized with 1.85 – 2.57 %day^{-1} already documented for *O. niloticus, C. gariepinus* and Heteroclarias fingerlings fed pawpaw seed meal and other seed meal-supplemented diets (Farrag *et al*., 2013; Aliu and Osaro, 2018; Michael and Mathias, 2020; Michael *et al*., 2021; Jibrin *et al*., 2021; Zulhisyam *et al*., 2021). The low feed conversion ratio (FCR) values (1.86 – 2.32) were not significantly different ($p > 0.05$) across the six treatments and implied improved diet utilization by the fish since, according to De Silva (2001), ideal FCR values range between 1.2 and 1.8 for fish fed adequately formulated diets. Lower FCR depicts higher protein conversion efficiency and is inversely correlated with better feed utilization by fish which yields better growth (Olele *et al*., 2013). The numerically least FCR value (1.86) attained by fish fed Diet 2 suggested that they efficiently assimilated and converted dietary protein to more biomass at 10% SPSM supplementation level. Similar FCR values (1.91 – 2.73) have been documented for *O. niloticus* and *C. gariepinus* fingerlings raised on pawpaw seed meal and other seed meal-supplemented diets (Farrag *et al*., 2013; Michael *et al*., 2021; Zulhisyam *et al*., 2021). The values of protein intake (8.39 – 11.97 g 100g diet/fish) equally implied better dietary protein assimilation when juxtaposed with 0.18 – 0.29 and 0.84 - 1.33 g 100g diet/fish respectively observed in *Heteroclarias* and *C. gariepinus* fingerlings in related studies (Anyanwu *et al*., 2008; Adesina and Ikuyeju, 2019). The protein efficiency ratio (PER) values (1.09 – 1.35) marginally agreed with 1.63 – 2.58 found in *C. gariepinus* fingerlings in similar studies (Babale, 2016; Oyelere *et al*., 2016; Bake *et al*., 2016, 2020; Jibrin *et al*., 2021) and comparatively suggested better dietary protein utilization than 0.1 – 0.38 documented for *C. gariepinus* fingerlings fed locust bean seed meal-supplemented diets

(Michael and Mathias, 2020). PER indicates how effectively the protein ingredients in a particular diet can release the necessary essential amino acids in the fish nourished with such a diet (Davis, 2004). Fish survival rate (70 – 85.5%) recorded in this study concurred with 75.0 – 86.66% previously reported for *O. niloticus* fingerlings fed pawpaw seed meal-supplemented diets (Farrag *et al*., 2013) and 67.03 – 92.35% recorded for *C. gariepinus* fingerlings in related studies (Jimoh *et al*., 2014; Aliu and Osaro, 2018; Nwose *et al*., 2021) while it signified better survival in comparison with 48.0 - 86.0% achieved by *C. gariepinus* fingerlings (Anyanwu *et al*., 2015). This fairly high survival rate possibly implied that supplementing soaked pawpaw seed meal in the diet of *C. gariepinus* juveniles did not cause severe fish mortality. It further suggested adequate acceptability of the prepared diets by fish which could be associated with good handling, adequate water quality management, suitable feed processing and suitability of soaked pawpaw seed meal incorporation in *C. gariepinus* diet.

Table 4: Growth performance and feed utilization indices of *C. gariepinus* juveniles fed graded levels of soaked pawpaw seed meal-supplemented diets

Growth and feed utilization indices	0%SPSM Diet 1 Control	10%SPSM Diet 2	20%SPSM Diet 3	30%SPSM Diet 4	40%SPSM Diet 5	50%SPSM Diet 6
Initial mean weight(g)	8.5±0.4^{a}	8.5±0.5^{a}	8.5±0.4^{a}	8.5±0.2^{a}	8.5±0.4^{a}	8.5±0.3^{a}
Final mean weight (g)	23.23±1.27^{bc}	24.7±2.0^{c}	22.3±1.5^{bc}	22.05±0.35^{bc}	21.34±1.14^{b}	17.63±1.67^{a}
Mean weight gain (g)	14.73±1.47^{bc}	16.2±2.7^{c}	13.8±0.9^{bc}	13.55±1.1^{bc}	12.84±0.76^{b}	9.13±0.42^{a}
Percentage weight gain (%)	173.29±6.21^{c}	190.59±8.99^{d}	162.45±3.2^{bc}	159.41±7.81^{b}	151.06±3.86^{b}	107.41±7.11^{a}
Specific growth rate (%day)	1.8±0.5^{b}	1.9±0.21^{b}	1.72±0.1^{ab}	1.7±0.1^{ab}	1.64±0.05^{ab}	1.3±0.03^{a}
Total feed intake (g)	1704.0±11.8^{e}	1811.4±7.8^{f}	1635.6±13.6^{d}	1617.0±8.0^{c}	1566.07±5.63^{b}	1293.0±9.0^{a}
Mean feed intake (g)	28.4±4.2^{b}	30.19±1.89^{b}	27.26±5.46^{ab}	26.95±2.45^{ab}	26.09±1.89^{ab}	21.55±2.75^{a}
Feed conversion ratio	1.93±0.06^{a}	1.86±0.12^{a}	1.98±0.48^{a}	1.99±0.16^{a}	2.03±0.68^{a}	2.32±0.43^{a}
Protein intake	11.4±1.5^{ab}	11.97±1.33^{b}	11.01±2.19^{ab}	10.81±0.4^{ab}	10.7±2.2^{ab}	8.39±1.81^{a}

Protein efficiency ratio	1.29±0.03[a]	1.35±0.06[a]	1.25±0.12[a]	1.25±0.07[a]	1.2±0.5[a]	1.09±0.14[a]
Nitrogen metabolism	487.75 ±4.25[c]	510.35±10.95[d]	473.46±6.54[bc]	464.28±15.11[b]	458.7±8.3[b]	401.67±8.33[a]
Percentage survival (%)	85.0±4.5[b]	85.0±5.2[b]	85.5±1.8[b]	70.5±4.8[a]	85.0±4.7[b]	70.0±3.6[a]

Mean values with different superscripts a, b, c, d, etc. along the same row are significantly different ($p < 0.05$). SPSM: Soaked Pawpaw Seed Meal

CONCLUSION

The results from this study have shown that soaked pawpaw seed meal can be used as an unconventional supplement in diet formulation for *C. gariepinus* juveniles. It was observed that 10% SPSM supplementation (Diet 2) yielded the best indices of growth performance, feed intake and utilization. Higher SPSM supplementation levels (20 - 50%) evidently caused progressively diminishing feed utilization and growth response. In view of this, other processing methods should be employed to broaden the scope of utilization of pawpaw seed meal in fish feed production for *C. gariepinus* and other cultivable species.

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Review of grey mullet culture in Nigeria

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ABSTRACT

Grey Mullet is a member of the family Mugilidae, order Mugiliformes. Mullet are ray-finned fish found worldwide in coastal temperature and tropical waters. They are nektonic, usually in shallow inshore environments, such as coastal bays, reef flats, tide pools and round harbor pilings and in brackish water estuaries and mangroves. These species are diurnal and feeds on zooplankton, benthic organisms and detritus. Mullet are usually farmed in polyculture; it can be stocked along with other species. Stocking density depends on the site locations and the fish species to be stocked with mullet. The culture of grey mullet totally dependent on the physical, chemical and biological environmental requirement of fish. Mullet are cultured in so many part of the world, usually in extensive and semi-intensive ponds system. Aquaculture production by species in Africa show that Egypt alone produce grey mullet which comes second among the other species produced in Africa with tilapia topping the list while Africa catfish is the third on the list. Catfish is the most common to Nigeria aquaculture production. Nigeria is blessed with six species of grey mullet which are common landing of most artisanal fishermen in coastal area such as Lagos lagoon, Bonny River and Niger Delta. Adequate information on mullet culture will increase the number of culturable fish species in Nigeria.

Keywords: grey mullet, mugilidae, culture, Nigeria

INTRODUCTION

Global production of Grey mullet, increased from 25,600 tonnes in 1997 to 147,000 tonnes in 2003. Most of the reported increase was the result of the increased production from Egypt, which is the largest producer (92% in 2003). According to the Food and Agricultural Organization of the United Nation (FAO, 2015), there are no clear trends in production in the other countries rearing

Grey mullet. Aquaculture production by species in Africa show that Egypt alone produce grey mullet which comes second among the other species produced in Africa with Tilapia topping the list while Africa catfish is the 3rd on the list (FAO, 2011). Thus, grey mullet ranked second in production volume, but its production is confined to Egypt, therefore Tilapia and catfish are the most commonly farmed species in other parts of Africa except Egypt. Catfish is the most common to Nigeria aquaculture production (Bhujel, 2014). Aquaculture in Nigeria is limited to few species. Nigeria is blessed with six species of grey mullet which are common landing of most artisanal fishermen in coastal area such as Lagos lagoon, Bonny River and Niger Delta (Fagade and Olaniyan, 1973 and King, 1984). Adequate information on Mullet culture will increase the number of culturable fish species in Nigeria. FDF (2015), and Oziegbo *et al.,* (2014) Reported that out of over 1027, 058 MT of various freshwater, brackish and marine water fish species produced between 2008 to 2015 grey mullet is very negligible 11,967 compared to Clariidae catfish production. (Oziegbo *et al.,* 2014).

The choice of species to culture is very important for the success of any aquaculture production (Ugwumba and Ugwumba, 2003). Mullet are fish species with good market value, its seed is available from wild all year round and have very high potential yield mostly when poly-cultured with other species (Deekae *et al.,* 1994, Ugwumba and Ugwumba 2003)

Importance and value of grey mullet

Grey mullet is a very important aquaculture species in so many countries. Mullet are abundant in the wild. The species can grow up to a length of 120 cm (Saleh 2008). In Nigeria mullet are very important to commercial fishery as they form major constituent of the fish landings of artisanal fishermen in the Niger Delta region (Akpan and Ubak 2005). Saleh (2008), reported that mullet fetch the best price where marketed fresh. It is also processed into dried, salted product. Their roe which in some area such as Egypt and far East, has relatively highly valued if sold fresh, salted and dried or smoked.

Culture of Grey Mullet

Mullet are cultured in many countries of the world, usually in extensive and semi-intensive pond systems. Egypt has a long history of mullet aquaculture (Saleh 2008). Mullet are usually grown in extensive, semi- intensive and netted enclosures in shallow coastal waters. According to Pilly and Putty (2005), Mullet can be polycultured successfully with many other fish including common carp, grass carp, silver carp, Nile tilapia and milkfish and can be reared in freshwater, brackish and marine water Saleh (2008).

In Nigeria, several trial of polyculture of mullet was carried out e.g Ezenwa (1977) (polyculture trial of mullet) and (common carp) and Anyanwu and Awa (1988) (mullet, tilapia, hemichromis and elops spp respectively). In Nigeria mullets are very important to commercial fishery as they form major constituent of the fish landing of artisanal fishermen in the Niger Delta region (Akpan and Ubak, 2005, Abdullahi and Okonji 2018).

Identification and distribution

Mullet are member of the Order mugiliformes, family mugilidae. Mullet are ray-finned fish found worldwide in coastal temperate and tropical waters. Some species are also in freshwater. Taxonomically the family is usually treated as the sole member of the order mugiliformes (Saleh

2008). Mullet is an extremely important fish cultured in many countries particularly Mediterranean. It has a worldwide distribution and they feed at the lowest trophic level (i.e plants, detritus and algae) (Smith and Swart, 1998, Abdullahi and Okonji, 2018).

According to Edward *et al.,* (2001) many species of Mullet enter fresh water and they generally swim in large schools. There are 25 species in this genus Mugilidae. However, only 16 species are recognized with Liza species having the last number (Menezes *et al*; 2015). Mullet can be found in the western part of Africa from senegal to Angola. *Liza falcippinis* is probably the dominant mullet in West Africa coast and contribute significantly to the mullet fishery in Nigeria (King 1988 and Abdullahi and Okonji, 2018).

Habitat

Most mullets are found in coastal marine and brackish waters. They are nektonic, usually in shallow inshore environments, such as coastal bays, reef flats, tide pools, and around harbor pilings and in brackish water estuaries and mangroves. They usually swim over sandy-muddy bottoms and sea grass meadows, in relatively still waters. They commonly occur at water depths of 20 m but may be found offshore or in deeper waters. Many species are euryhaline and move between marine and freshwater environments of rivers and flooded rice fields. Some species occasionally swim far up river, while a few species spend their entire adult lives in rivers (Smith and Smith, 1986; Cardona, 2006). They are catadromous, frequently found in estuaries and freshwater environments. Adult mullet have been found in waters ranging from zero salinity to 75 ppt, while juveniles can only tolerate such wide salinity ranges after they reach lengths of 4–7 cm (Cardona, 2000). Adults form large schools near the surface over sandy or muddy bottoms and dense vegetation and migrate offshore to spawn in large aggregations (Eschmeyer, *et al*, 1983). The larvae move inshore to extremely shallow water, which provides protection from predators as well as a rich feeding ground. After reaching 5 cm in length, the young mullets move into slightly deeper waters (Saleh, 2006)

Feeding

The species is mainly diurnal and feeds on zooplankton, benthic organisms and detritus. Adult fish tend to feed mainly on algae. The success of mullet aquaculture is also a result of its feeding habits. Mullet are usually farmed in polyculture with other fish species in earthen ponds. Enhancing natural food production in the ponds through artificial fertilization is important as this reduces considerably the requirements for manufactured feed. In the Egyptian polyculture system, natural food covers 25–50 percent of the food requirement of the cultured fish (tilapia, carps) while the farmed mullet depend totally or to a very large extent on natural food. Cultured mullet are sometimes supplied with wheat or rice bran during the late nursery stage or when cultured as the main component of the fish stocks. Chicken manure is also used successfully as fertilizer to boast natural food for mullet in nursery and on-growing ponds.

Stocking Density

In countries where most cultured mullet are produced, pre-farming preparation of ponds is of great importance. Prior to stocking, culture ponds are prepared by drying, plowing and fertilization. Ponds are filled to depth of 25-30cm and kept at level, subsequently increased to 1.5 -1.75m and the fingerlings are stocked (Saleh 2008). In intensive polyculture of mullet in freshwater or slight

saline waters in Hong Kong, Israel, Egypt and India. Stocking is done at the rate of 10,000-15000 mullet/ha, along with 1000-2000 chinese carp fingerling/ha. In Taiwa, the stocking rate/ha is reported to be about 3000 Mullets, 2000 Milkfish, 3250 Chinese and 500 Common Carp (Pillay and Kutty, 2005).
According to Saleh, (2008) Acclimatization to the appropriate salinity and stocking about 10-15g individual at about 6200-7400/ha, a harvest of 4.3-5.6/tonnes/ha/crop can be obtained. In semi-intensive polyculture with tilapia and carp, mullet fingerlings are stocked at about 2500-3700/ha together with 1900-2500/ha of 100g size of common carp juveniles and about 62000-74000/ha of 10-15g Nile tilapia fingerlings. Total harvest are typically 20-30 tonnes/ha/crop of which 2-3 tonnes are mullets. After an on-growing season of 7-8 month. Grey mullet reach an individual weight of 0.74-1kg. The choice of rearing depend on market demand and economics (Saleh, 2008)

Environmental Requirement

The optimum fish production is totally dependent on the physical, chemical and biological environmental requirement of fish. Fish do not like any kind of sudden changes in their environment. Sudden changes may lead to stress (Bhatnager and Devi, 2013). All culturable freshwater/brackish water fish species has a wide range of tolerance to all the environmental changes (NAERLS 1996). The optimum ranges for various fresh water quality parameters for aquatic organism is shown in table 1.

Table 1. The optimum range of various fresh water quality parameter summary

Parameter	Acceptable Range	Desirable range	Stressful
Temperature ^{0}C	15-35	20-30	<12, >35
Transparency (cm)		30-80	<12, >80
Dissolve Oxygen (mg/l)	3-5	5	<5, >8
BOD (mg/l)	3-6	1-2	>10
CO_2 (mg/l)	0-10	<5 5-8	>12
PH	7-9.5	6.5-8.5	<4, >10
Alkalinity (mg/l)	50-200	25-100	<20,>300
Ammonia (mg/l)	0-0.05	0-0.025	> 0.3
Nitrite(mg/l)	0.02-2	<0.02	>0.2
Nitrate(mg/l)	0-100	0.1-4.5	>100<0.01
H_2S (mg/l)	0-0.02	0.002	Any detectable level
Plankton (No./L)	2000-6000	3000-4500	<3000>7000

Source (Bhatnagar and Devi 2013).
These above mentioned environmental guideline if taken into consideration will raise productivity and economic benefits in ponds environment required for suitable fish culture/aquaculture.

Suitable Culture System

Mullet are cultured in so many part of the world, usually in extensive and semi-intensive pond system (Eisawy and El-Bolok, 1975 and Crosetti, 2016). The traditional extensive culture of mullets together with other euryhaline species using brackish water still continues to be an important culture practice (Pillay and Kutty, 2005). In Italy, mullet farming is almost entirely based on extensive technique, with coastal lagoon and semi- intensive ponds being restocked with wild juveniles (Landoli 2000).

Saleh (2008) reported that, mullet are usually grown in extensive, semi- intensive and netted enclosures in shallow coastal waters. Mullet can be polycultured successfully with many other fish including common carp, grass carp, silver carp Nile tilapia and milkfish and can be reared in freshwater, brackish and marine water. Pillay and Kutty (2005), also reported that in Hong Kong and Taiwan, mullet are cultured in combination with Chinese carp, in Israel and Egypt with common carp and tilapia and in India with milkfish and pearspot and other estuarine species. The growing season is normally about 7-8 month under semi-intensive culture system. In Nigeria, several trial of polyculture of mullet was carried out e.g Ezenwa (1977) (polyculture trial of mullet) and (common carp) and Anyanwu and Awa (1988) (mullet, tilapia and elops spp respectively).

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Genetic Differentiation of Farmed Cichlid Species and their Reciprocal Hybrids

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ABSTRACT

Cichlid species, Oreochromis niloticus and ecotype, Wesafu are of nutritional and economic importance with relevant aquaculture potential. They dominate tropical and sub-tropical fresh waters of Africa and have been successfully domesticated and hybridized reciprocally. However, differentiating them most times especially during culture is difficult. On this note, molecular characterization of pure stocks of cichlid especially ecotype cichlid, Wesafu that is unidentified and their reciprocal hybrids is necessary to determine their genetic variability for proper management in aquaculture production. This study utilized eight microsatellite loci to investigate and characterize two cichlid pure stocks (Oreochromis niloticus and ecotype, Wesafu) and their reciprocal hybrids. DNA was isolated from the clipped caudal fins of the cichlid species, amplified and further resolved on 6% polycarylamide gel electrophoresis (PAGE). The microsatellite analysis revealed that the hybrid from crossing between female O. niloticus and male ecotype, Wesafu (♀O. niloticus x ♂ Wesafu) had the highest genetic diversity as was evidenced by heterozygosity (He = 0.71) and shannon index (0.72) compared to others. Genetic relatedness was observed between O. niloticus pure stock and the female O. niloticus and male ecotype, Wesafu (♀O. niloticus x ♂ Wesafu) hybrid in the dendrogram. This finding provides genetic information for better breeding and management of these species in aquaculture production.

Key words: Molecular characterization, microsatellite analysis, Tilapia, pure stock, hybrid,

INTRODUCTION

Cichlid species (*Oreochromis niloticus* and ecotype, Wesafu) dominate tropical and sub-tropical fresh water of Africa and grow bigger than some other cichlid species particularly the ecotype, Wesafu which is unidentified and commonly found in Epe lagoon of Lagos State (Megbowon and

Fashina-Bombata, 2013). They have good nutritional, economic and aquaculture relevance which are all explored for food security in Nigeria. Furthermore, hybrids production has been of great importance to aquaculture production especially in Nigeria where different tilapia species have been cultivated. It is through hybridization that the desirable traits of selected species can be combined for fish growth enhancement and improved aquaculture production. Thus, aquaculture industry has increased through tilapia hybridization. Increased aquaculture production is greatly needed due to the global population expansion in order to meet the global demand.

According to Luo *et al*. (2015), understanding the genetic differentiation between wild and cultured populations will help inform proper management strategies and conserve wild genetic resources. Microsatellite markers have proven to have great discriminatory power as codominant for the evaluation of genetic diversity between wild and cultured aquaculture populations of cichlid species (Zhu *et al*., 2011). The present study is therefore focused on the investigation of the genetic variation of these cichlid species vis-à-vis their reciprocal hybrids which will form the basis for improved breeding programs of Tilapia aquaculture.

MATERIALS AND METHODS

Twenty specimens were taken from each of the cichlid species (*O. niloticus* and ecotype, Wesafu) and their reciprocal hybrids; female *O. niloticus* with male ecotype, Wesafu (♀*O. niloticus* x ♂ Wesafu) and female ecotype, Wesafu and male *O. niloticus* (♀Wesafu and ♂ *O. niloticus*) from fish hatchery of Nigerian Institute for Oceanography and Marine Research Lagos, Nigeria. Genomic DNA was extracted from the muscle tissue (1 cm^2) of the experimental fish using modified phenol-chloroform method. The purity check for the extracted DNA quality was done using a Nano-drop spectrophotometer at absorbance of 260/280nm and was further amplified in a thermocycler with eight microsatellite primers. The amplicons were separated on polyacrylamide gel electrophoresis (PAGE) at 6% concentration and 80 V for 2 h in a 1x TBE buffer.

Data Analysis

Genetic data generated was analyzed using POPGENE version 1.32 to obtain the number of alleles, effective number of alleles, Shannon information index, fixation index, observed heterozygosity and expected heterozygosity while the UPGMA dendrogram was used to determine the genetic relationship between the cichlid pure stocks and their reciprocal hybrid.

RESULTS AND DISCUSSIONS

DNA markers have been confirmed satisfactory to evaluate the genetic variability of two cultured strains of O. *niloticus* (Espindola de Souza, 2007). The microsatellite analysis revealed that the hybrid of female *O. niloticus* and male ecotype, Wesafu (♀*O. niloticus* x ♂ Wesafu) had the highest mean number of alleles (2.25), followed by the parents (*O. niloticus* and ecotype, Wesafu) with 2.00 mean number of allele respectively while the lowest was found in the hybrid of female ecotype, Wesafu and male *O. niloticus* (♀Wesafu and ♂ *O. niloticus*) (1.62).

The mean effective alleles varied from 1.37 to 1.98. In all, the mean effective number of allele was lower than the number of alleles. Shannon information index showed higher in ♀*O. niloticus* x ♂ Wesafu hybrid (0.72) followed by the parents reflecting high genetic diversity and the ♀Wesafu and ♂ *O. niloticus* hybrid had low index. The ♀*O. niloticus* x ♂ Wesafu hybrid was more variable

(He = 0.71) than the parents and ♀Wesafu and ♂ *O. niloticus* hybrid. Gene diversity was observed highest in ♀*O. niloticus* x ♂ Wesafu hybrid than others as shown in Table 1. The cross between the female *O. niloticus* and male ecotype, Wesafu (♀*O. niloticus* x ♂ Wesafu) hybrid was observed to have the most diversity as demonstrated by the number of alleles, Shannon's information index and heterozygosity which were higher in this hybrid when compared to the pure stocks that were observed to be less variable. Thus, ♀*O. niloticus* x ♂ Wesafu hybrid exhibits higher genetic diversity than the founder stock and might be attributed to poor selection and breeding management method observed by breeders. Therefore, adequate genetic monitoring should be considered for appropriate management of these genetic stocks.

Table 1: Summary of the genetic diversity level in the studied Cichlids and their Hybrids

Population		Na	Ne	I	He	GD	F
O. niloticus	**Mean**	2.000	1.642	0.553	0.603	0.359	-0.549
	SE	0.327	0.311	0.129	0.158	0.085	0.138
Wesafu	**Mean**	2.000	1.756	0.596	0.682	0.400	-0.720
	SE	0.378	0.304	0.137	0.152	0.089	0.098
OWhybrid	**Mean**	2.250	1.986	0.719	0.710	0.478	-0.491
	SE	0.164	0.159	0.065	0.058	0.033	0.091
WOhybrid	**Mean**	1.625	1.372	0.461	0.476	0.306	-0.468
	SE	0.375	0.340	0.134	0.145	0.089	0.102
Total	**Mean**	1.969	1.689	0.582	0.618	0.386	-0.552
	SE	0.159	0.142	0.059	0.066	0.039	0.054

Na: Number of alleles; Ne: Number of effective alleles; I: Shannon's Information Index; He: Observed heterozygosity; GD: Gene diversity or expected heterozygosity; F: Fixation index

OWhybrid: ♀*O. niloticus* x ♂ Wesafu, WO hybrid: ♀Wesafu and ♂ *O. niloticus*

The UPGMA dendrogram based on the genetic distance revealed two clusters: Cluster-1 consists of *O. niloticus* pure stock, female *O. niloticus* and male Wesafu (♀*O. niloticus* x ♂ Wesafu) hybrid and Wesafu pure stock suggesting genetic similarity between them while cluster-2 consists of female Wesafu and male *O. niloticus* (♀Wesafu and ♂ *O. niloticus*) hybid that clustered separately (Fig. 1) indicating a slight genetic divergence which might be due to hybridization. The genetic similarity between the *O. niloticus* pure stock and its hybrid might be attributed to single ancestry which is in line with the finding of Agbebi *et al*. (2016).

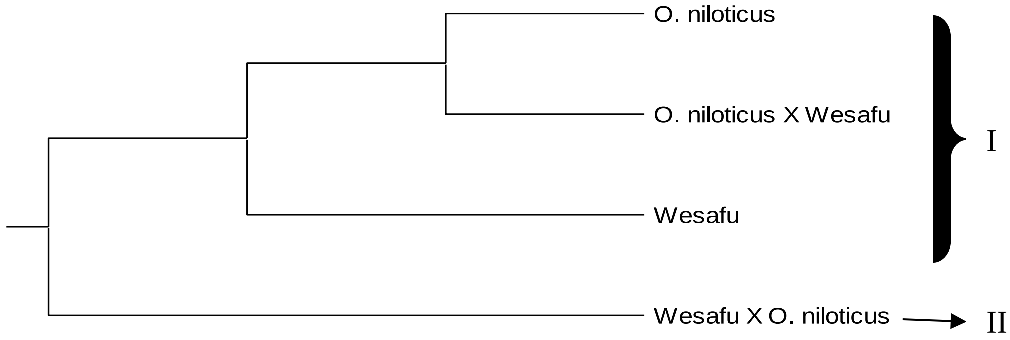

Figure 1: Dendrogram showing the Genetic Relationships among Cichlids Pure Stocks and their Hybrids

CONCLUSION

The female *O. niloticus* and male ecotype, Wesafu (♀*O. niloticus* x ♂ Wesafu) hybrid revealed high level of genetic variability with positive heterosis than the parents (pure stocks). This finding provides an insight for the proper management of these species and better breeding program.

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Effects of Smoking and Spices on the Microbial quality of African Catfish (*Clarias gariepinus*) from a fish farm in Alimosho Area of Lagos state, Nigeria.

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ABSTRACT

Fish is a worldwide a good source of protein especially in the developing countries like Nigeria. It supplies the body with needed proteins necessary for growth, replacing worn out tissues and wellbeing of individuals. Spices are seeds, fruits, roots, barks, or other plant substance primarily used for flavoring, coloring food an as antimicrobial agents used in the preservation of food materials including fishes, they maybe bactericidal or bacteriostatic in action. The microbial quality of raw and smoked cat fish (with and without spices) was assessed to determine its wholesomeness and edibility and to determine the effectiveness of spices as an antimicrobial agent. Raw fish samples were purchased, divided into three parts namely raw, smoked without spices and smoked with spices after which they were all assessed for microbial contamination with regards to the effectiveness of spices. Smoked fish samples, the spiced and the unspiced were examined organoleptically, Potato Dextrose Agar (PDA) and Nutrient Agar (NA) were used to enumerate the mould/yeast and bacteria load of the raw and smoked fish respectively while appropriate selective media (*Salmonella-Shigella* Agar, Mannitol Salt Agar) were used for the isolation *Salmonella* spp., *Shigella* spp., and *Staphylococcus aureus*. The total bacteria count was 2.0 x10^4 cfu/g for raw, 2.0 x10^4 cfu/g for smoked unspiced fish, 1.0 x10^4 cfu/g for spiced smoked fish. There was no fungal growth in the raw fish sample, 5.0 x 10^4 cfu/g for smoked unspiced sample, 3.0 x 10^4 cfu/g for the smoked spiced fish sample. The result showed that no *Escherichia coli* or *Salmonella species* was found on the smoked fish. Generally, the total bacteria count was higher than the mould/yeast count in samples A (raw fish) while in samples B (smoked fish without spices) and C (smoked fish without spice) the mould growth exceeded that of the bacteria. The sensory evaluation of the smoked fish showed that the fish was generally acceptable in taste and flavour, most especially the spiced one. In conclusion, smoked *C. gariepinus* is of high

microbiological standard, the spices reduced microbial load which confirms the antimicrobial potential of the spices.

Keywords: Catfish, Spices, Smoking kiln, Bacteria, Mould.

INTRODUCTION

African catfish (*Clarias gariepinus*) is one of the most common aquaculture species in Africa water (Dauda *et al.,* 2018). It is widely distributed throughout Africa, inhabiting tropical swamps, lakes, and rivers, some of which are subjected to seasonal drying (FAO, 2016b). African catfish consumption is on the increase in both rural and urban centers of Nigeria (Emikpe *et al.*, 2011; Adedeji *et al*, 2012). Fish is an important food commodity in the international trade but deteriorate rapidly when storage facilities are lacking (Adedeji *et al.*, 2012). Catfish is highly perishable and therefore requires careful handling and preservation to extend its shelf life and maintain its desirable quality and nutritional content. Spices and herbs have been in use for long as far back as 19^{th} centuries where they were used mainly to improve flavor and aroma and of course for preserving foods and their medicinal value (antimicrobial properties), (Zaika, 1998, Khalaf *et al.*, 2008). Spoilage of raw fish is primarily bacterial in nature while fungi may be responsible for the spoilage of the smoked one, but other factors such as enzymatic break down of the tissue contribute to spoilage. About 30% of landed fish are lost through microbial activity alone (Ghaly *et al.,* 2010). The microbial flora associated with fish is sometimes a reflection of their aqueous environment (Arafat, 2013). Water being a natural habitat for a wide range of microorganisms including bacteria, protozoa and fungi (Sumer *et al.,* 2014), fish take in or harbour these organisms from its environment. These organisms may be pathogenic to fish including humans when ingested. Thus, the need to assess the microbial load of the catfish (raw, smoked with spice and smoked without spice) with a view to determining their edibility and to ascertain the potency of spices as an antimicrobial agent (Arafat, 2013).

MATERIALS AND METHODS

(i) Sample collection: 20kg of live catfish samples (*Clarias gariepinus*) were purchased from a reputable fish farm at Command Alimosho, Lagos, and transported in oxygen bag immediately to Sofunks Food Processing unit, Command Ajasa Alimosho, Lagos for smoking according to the method of Omojowo and Ibitoye (2005). 15kg (7.5kg each for spiced, made up of blended garlic and ginger, and unspiced) of the fish were smoked at 75^{o}c for 48hrs while the remaining raw sample (5kg) was transported in an ice box to the Microbiology Laboratory of Fish Technology Department, NIOMR within one hour of purchase for microbiological assessment.

(ii) Sensory evaluation: this was carried out according to the method of Afolabi *et al.*, (1984).

(iii) Preparation of Sample for Microbial Analysis: In an aseptic manner, portions of the samples were taken with a scalpel, homogenized in peptone water with a clean, sterile electric blender. An aliquot (5g), was introduced into 45ml of sterile distilled water, homogenized, and inoculated on Nutrient Agar, Salmonella-Shigella Agar, Mannitol Salt Agar and Potato Dextrose Agar using standard microbiological methods. The plates were incubated at 37^{o}C for 24hours for bacteria and at room temperature for fungi (Fawole and Oso, 2007).

(iv) Bacteria Colony Count: After incubation, colonies were enumerated, and the results were expressed as colony forming unit per gram (cfu/g) of the samples. Discreet colonies were sub-cultured into fresh agar plates aseptically to obtain pure culture of the isolates, (Fawole and Oso, 2007).

(v) Characterization and Identification of the Isolates: The isolates were identified in terms of their colony characteristics, microscopy and biochemical tests as described by Fawole and Oso, (2007).

(vi) Analysis of variance (ANOVA), Duncan F-Test was used as the statistical tool for the results

RESULTS

The results of the assessment of the bacteriological quality of cat fish are presented in tables below. The results obtained from the total heterotrophic mean count of bacteria in fresh, smoked spiced and unspiced smoked cat fish shows that raw fish recorded the highest mean count of 2.0 x10^4cfu/ml followed by the smoked unspiced with bacterial count of 2.0 x10^4cfu/ml while spiced smoked had the least count of 1.0 x10^4cfu/ml (Table 1).

Suspected bacteria from the catfish include *Bacillus subtilis, Pseudomonas* sp., *Bacillus cereus*, *Alcaligenes* sp., *Enterococcus* spp. While fungi include *A. niger*, *A. flavus*, *R. stolonifer* and *Penicillium* sp.

Based on fungal frequency of occurrence, *Aspergillus niger* had the highest followed closely by *A. flavus* and *Rhizopus stolonifer* and the least frequent was *Penicillium* sp. Enteric organisms were not detected and this made the samples to be safest for consumption

Effects of smoking and spices on the microbial load and sensory evaluation results follow thus

Table 1: Bacterial and fungal counts of the catfish samples

Samples	NA cfu/ml (10^4) for bacterial count	PDA cfu/ml (10^4) for fungal count
Raw	2.0	-
Smoked unspiced	2.0	5.0
Smoked spiced	1.0	3.0

table 2: fungal isolates occurrence from the catfish samples

Isolates	Number of appearances	% occurrence
Aspergillus niger	5	33
Aspergillus flavus	4	27
Rhizopus stolonifer	4	27
Penicillium sp.	2	13

Table 3: Sensory evaluation of the fish sample using ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
APPEARANCE	Between Groups	6.400	1	6.400	11.472	.002
	Within Groups	21.200	38	.558		
	Total	27.600	39			
TASTE	Between Groups	1.600	1	1.600	2.764	.105
	Within Groups	22.000	38	.579		
	Total	23.600	39			
TEXTURE	Between Groups	.900	1	.900	2.631	.113
	Within Groups	13.000	38	.342		
	Total	13.900	39			
FLAVOUR	Between Groups	2.500	1	2.500	8.333	.006
	Within Groups	11.400	38	.300		
	Total	13.900	39			
GENERAL ACCEPTABILITY	Between Groups	.400	1	.400	.792	.379
	Within Groups	19.200	38	.505		
	Total	19.600	39			

DISCUSSION

From the results of this study, it was discovered that microbial loads of the raw catfish showed a slight difference from the spiced smoked and unspiced smoked fish samples and this could be attributed to the fish habitat which isn’t free from anthropogenic activities and human waste disposals. This can be compared with the work done by Adebayo-Tayo *et al.*, (2012) who also reported a slight varying load of isolates from raw and smoked catfish. Comparing the fresh and dry catfish, it was discovered that bacterial loads of the fresh catfish sample was more than that of the smoked owing to the water availability which is a condition for microbial attack and deterioration but fungal load in the smoked fish samples is more than that of the raw fish, this could be as a result of low water activity which favours fungal manifestation.

Organisms such as *Bacillus subtilis, Pseudomonas* sp., *Bacillus cereus, Alcaligenes* sp., *Enterococcus* spp., among others were suspected to be present in the fish samples. This was in agreement with the wok of Osuntokun *et al.*, (2020), who isolated similar organisms from catfishes from earthen and concrete tanks.

Smoking and spices, which maybe antimicrobial in nature, may also be a contributing factor in the reduction in the microbial load for the spiced fish sample. These spices do not only reduce water availability which is a condition for fungal growth but also impair microbial cell formation. As a result of this, spiced smoked fish sample had least microbial growth.

CONCLUSION AND RECOMMENDATION

From the results obtained, it could be concluded that raw fish harbour more of bacteria possibly because of the habitat and human handling while smoked fish samples had more of fungal growth. Spices being antimicrobial in nature affects both spoilage microorganisms and human pathogens by reducing the microbial load in the fish sample there by making it more suitable for consumption and wider acceptability amongst the consumers. Sensory evaluation also showed that the spiced fish sample is more acceptable by consumers because of its taste. It is therefore concluded that smoking at the appropriate temperature as well as the addition of spices reduce microbial load in both raw and smoked fish. It is therefore suggested that contamination and re-contamination can be minimized by avoiding fish exposure to harmful chemicals, increase in hygiene of the retailers and adequate measures should be taken while harvesting, preserving and processing the fish before consumption and the use of spices, which are sourced from natural herbs that are generally regarded as safe.

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Quality changes in ready-to-eat shrimp cracker as influenced by storage temperatures

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ABSTRACT

The study examined the effects of storage on the quality of a ready-to-eat shrimp cracker at two different temperatures. The proximate composition and sensory attributes of the ready-to-eat (RTE) shrimp cracker were evaluated during the storage of the product for 12 months. Results of Proximate analysis on the samples showed a reduction in protein, lipid, and moisture content and increases in ash and crude fiber at both storage conditions. Sensory evaluation of the shrimp cracker samples at both ambient and refrigerated temperature storage revealed a reduction in quality of the samples with respect to taste with increasing duration of storage, even as the best quality (texture, odor and color) was obtained at the start of the experiment. The ready-to-eat shrimp cracker should be consumed shortly after purchase to maximize freshness of the product. Thus, storage temperature and duration seemed to have unpleasant effects on the nutritional quality of ready-to-eat shrimp cracker.

Key words: Shrimp cracker, ambient storage, refrigerated storage, proximate composition, sensory, ready-to eat

INTRODUCTION

The desire and demand for healthy foods, snacks inclusive, that are made up of dietary fiber has grown tremendously (Idowu *et al*.,2019). This increased demand for healthy snack foods, which are quick sources of good nutrition, has resulted in the development of food products which combine convenience and nutrition (Ahmed and Abozed,2014; Sreelakshmi and Ninan,2018).These low cost foods seem to have gained wide popularity when compared with other processed foods based on their good nutritional quality and availability in various forms, their varied taste and longer self-life (Hussein *et al*.,2011). As ready to eat, convenient and inexpensive food products, they tend to possess digestive and dietary principles of vital importance(Idowu *et al*.,2019).

One of such important traditional fish-based snack food is the crackers, usually defined as biscuits that are more or less unsweetened, salty, thin and crispy with very low sugar and fat content (Uchegbu and Ishiwu, 2015). They are produced by gelatinization of starchy dough that is shaped into different forms before drying. Asides the two essential components of crackers which are starch and water, other ingredients, such as fish or other types of seafood, e.g shrimp, crab are usually added to produce different types of crackers (Vasanti *et al*.,1996).Crackers made from cassava starch and shellfish, properly formulated with adequate nutritional and sensory qualities, have the potential of being a source of essential nutrients for children and teenagers (Kolade *et al*.,2014).

Seafood products which include fish crackers, fish cakes, fish balls and fish burgers made from fish or other seafood are suitable ready-to-eat foods preferred by consumers around the world and numerous studies have been conducted on the production, quality, and stability of these food products(Cakli *et al*., 2005).However, seafood and their products can undergo undesirable changes during processing and storage of such food products, thus resulting in deterioration which may limit their shelf life. These undesirable changes emerge majorily from protein denaturation and lipid oxidation (Siddaiah *et al*., 2001; Benjakul *et al*., 2005).Previous works has conducted on the quality changes in seafood-based ready-to-eat products from different parts in the world, aiming especially at the microbial activity development and degree of safety (Oh *et al*., 2007; Meloni *et a*l., 2009; Miya *et al*., 2010; Kim *et a*l., 2011).

There seems to be paucity of information on quality changes that occur in shrimp crackers during storage with respect to temperature conditions. Based on this, the study sought to examine the nutritional and sensory changes that occur during storage of such ready-to-eat shrimp crackers for 12months under ambient and refrigerated conditions respectively.

MATERIALS AND METHODS

Sample Collection: Three (3) cartons of samples of ready-to-eat (RTE) shrimp crackers were obtained from a wholesale shop at Mushin, Lagos. Each carton was made up of twenty (24) vacuum packed samples with each sample containing 25g of the product. The carton of the shrimp crackers were transported to the Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos for analysis. At the laboratory, 21 packs of the vacuum packed shrimp crackers were placed in a refrigerator (4°C) while another 21 packs of the products were left in the product carton and placed in a dry corner in the laboratory under ambient temperature (28^{o}C). The shelf life of the ready to-eat product under ambient conditions was indicated on the product pack and was indicated to be 10months. However, the present study was designed to reach such expiration date and surpass it. Thus, sampling of the product was carried out every other month for 7 times (month 0,2,4,6,8,10,12). Three packs of the vacuum packed products were taken from the refrigerated and ambient stored shrimp crackers respectively for proximate composition analysis and sensory evaluation at each sampling time. Each pack of the sample was opened, broken into smaller bits and then blended into powdery form. Five grams (5g) was taken from the blended the refrigerated and ambient stored shrimp cracker samples respectively and analyzed separately. In order to achieve the statistical analysis (n = 3) analyses were carried out in triplicates on the homogenized ready-to-eat shrimp cracker.

Proximate Composition Determination
Proximate composition of samples was determined using Association of Official Analytical Chemistry (A.O.A.C) methods (1994). All analyses were done in triplicates.

***Moisture Content**:*-This was estimated by drying samples to constant weight at 103 ± 20^{o}C using the oven dry method.

***Lipid Determination**:*-This was carried out using the modified Bligh and Dyer procedure (1959).

***Protein Content**:*-The protein content of the crackers was estimated by Kjedahl method as described by
(Vlieg,1984).This method involved the estimation of the amount of nitrogen in the sample and subsequent multiplication by a factor of 6.25.

Ash content :-The ash content of the shrimp cracker samples were determined by igniting the samples at 550^{0}C for about 5-6 hours until the samples was completely free of carbon particles in a carbolite Sheffield LMF3 muffle furnace. This was done based on Association of Official Analytical Chemistry(A.O.A.C) methods (1994).

Sensory Evaluation
Sensory Evaluation of the product was carried out using a 10-point Hedonic scale (Amerine *et al*.,1965) while assessing the samples for parameters such as taste, appearance, texture, color, odor and general acceptability. The organoleptic scoring for the shrimp cracker was rated as 1 for dislike extremely, 2 for dislike very much, 3 for dislike moderately, 4 for dislike slightly, 5 for neither like nor dislike, 6 for like slightly, 7 for like moderately, 8 for like very much, 9 for like extremely. Mean score 6 was considered as good and below 5 as poor or unacceptable. Panelists were given an opportunity to make additional comments.

Statistical Analysis
Samples were analyzed in triplicates even as mean values and standard deviations were calculated and results were expressed as mean ± SD. Analysis of variance (one-way ANOVA) was carried out using SPSS (IBM SPSS statistics version 16). Duncan multiple range test was employed to determine statistical differences of mean values at ($P \leq 0.05$).

RESULT
Mean nutrient compositions of the ready-to eat shrimp cracker stored under ambient temperature and refrigerated temperature are shown in tables 1&2.The results showed a gradual decline in the quantities of the nutrients of the ready-to eat shrimp cracker at both ambient and refrigerated temperature conditions. Percentage crude protein dropped from 5.22% to 5.07% during ambient storage while it dropped to 5.09% in refrigerated storage temperature(4^{0}C). Lipid content of the shrimp cracker which was 7.8% at the start of the experiment dropped to 7.45% at ambient temperature storage and to 7.47% at refrigerated temperature storage (Tables 1& 2).There was also a reduction in moisture content of the ambient stored shrimp cracker from 5.93% to 5.75% ,and from 5.93% to 5.80% for the refrigerated stored shrimp cracker. Furthermore, an increase was observed in the ash content of the shrimp crackers stored at ambient temperature and refrigerated temperature conditions respectively.

Table 1: Proximate composition of Ready-to-eat Shrimp Shrimp Cracker at Ambient Temperature condition (28^{0}C).

Storage Period (Month)	Protein (%)	Lipid (%)	Moisture (%)	Ash (%)
0	5.22 ± 0.06^{a}	7.8 ± 0.2^{a}	5.93 ± 0.23^{a}	4.70 ± 0.29^{a}
2	5.19 ± 0.12^{ab}	7.76 ± 0.7^{a}	5.9 ± 0.21^{ab}	4.78 ± 0.29^{a}
4	5.20 ± 0.12^{ab}	7.52 ± 0.29^{ab}	5.87 ± 0.5^{bc}	4.82 ± 0.12^{a}
6	5.15 ± 0.12^{c}	7.50 ± 0.5^{bc}	5.85 ± 0.25^{bc}	4.92 ± 0.12^{a}
8	5.13 ± 0.58^{c}	7.48 ± 0.29^{cd}	5.83 ± 0.29^{cd}	5.02 ± 0.5^{ab}
10	5.10 ± 0.5^{cd}	$7.42 \pm 0.^{14de}$	5.81 ± 0.29^{cd}	5.03 ± 0.29^{b}
12	5.07 ± 0.35^{d}	7.45 ± 0.35^{e}	5.75 ± 0.35^{d}	5.15 ± 0.35^{c}

Results are expressed as mean ± S.D. of 3 determinations.

Table 2: Proximate composition of Ready-to-eat Shrimp Cracker at Refrigerated Temperature Storage (4^{0}C).

Storage Period (Month)	Protein (%)	Lipid (%)	Moisture (%)	Ash (%)
0	5.22 ± 0.06^{a}	7.8 ± 0.25^{a}	5.93 ± 0.23^{a}	4.70 ± 0.29^{a}
2	5.21 ± 0.12^{a}	7.7 ± 0.17^{a}	5.90 ± 0.58^{a}	4.73 ± 0.12^{ab}
4	5.20 ± 0.5^{a}	7.72 ± 0.25^{b}	5.86 ± 0.5^{abc}	4.73 ± 0.29^{a}
6	5.18 ± 0.5^{ab}	7.67 ± 0.25^{c}	5.86 ± 0.12^{abc}	4.83 ± 0.29^{abc}
8	5.16 ± 0.50^{abc}	7.61 ± 0.29^{bc}	5.85 ± 0.29^{bac}	4.88 ± 0.29^{bc}
10	5.14 ± 0.29^{bc}	7.60 ± 0.29^{c}	5.82 ± 0.5^{cd}	5.09 ± 0.36^{c}
12	5.09 ± 0.12^{c}	7.47 ± 0.16^{d}	5.80 ± 0.58^{d}	5.17 ± 0.58^{c}

Results are expressed as mean ± S.D. of 3 determinations. Test values carrying different superscripts differ from one another across the rows ($P<0.05$).

Tables 3&4 show the organoleptic score ratings for the diverse parameters of the RTE shrimp cracker stored at ambient and refrigerated temperature conditions. The results showed a gradual decline in quality of the product based the ratings for the parameters of the ready to eat shrimp crackers stored at both ambient and refrigerated temperature conditions respectively.

A decline in the quality of product based on the organoleptic assessment seemed to be more apparent in the sample stored at ambient temperature as scoring for appearance, taste and texture dropped from 8.08 to 7.78, from 7.75 to 7.25 and from 7.67 to 7.40 respectively. Color and odor rating declined from 7.67 to 7.52 and from 7.67 to 7.45 respectively. The overall acceptability rating for the product at ambient storage dropped from 7.83 to 7.62.

For the shrimp cracker sample stored at refrigerated temperature, organoleptic score ratings for appearance, taste and texture reduced slightly from 8.08 to 7.80, 7.75 to 7.50 and 7.67 to 7.50 respectively. Color and odor score ratings dropped slightly from 7.67 to 7.53 and 7.67 to 7.56 respectively. The overall score rating for the refrigerated shrimp cracker declined from 7.83 to 7.66.

Table 3. Sensory Evaluation of RTE Shrimp Crackers at Stored At Ambient Temperature(28^{0}C).

Storage Period (Months)	Appearance	Taste	Texture	Color	Odor	Overall Acceptability
0	8.08 ± 0.08^a	7.75 ± 0.09^a	7.67 ± 0.23^a	7.67 ± 0.40^a	7.67± 0.03^a	7.83± 0.16^a
2	8.04 ± 0.21^{ab}	7.73 ± 0.11^a	7.64± 0.11^{ab}	7.62 ± 0.81^a	7.65 ± 0.27^a	7.80± 0.28^a
4	8.00 ± 0.11^b	7.71± 0.16^a	7.60 ± 0.18^b	7.60 ± 0.53^a	7.63± 0.12^a	7.74 ± 0.62^{ab}
6	7.90 ± 0.03^b	7.70± 0.13^b	7.60 ± 0.23^b	7.58± 0.71^{ab}	7.63± 0.17^a	7.71± 0.76^b
8	7.82 ± 0.21^c	7.55± 0.02^c	7.58 ± 0.03^b	7.56 ± 0.11^b	7.60± 0.30^{ab}	7.60± 0.34^c
10	7.80 ± 0.33^c	7.55± 0.04^c	7.50 ± 0.61^c	7.55± 0.21^b	7.58± 0.61^b	7.67± 0.12^c
12	7.78 ± 0.18^{cd}	7.25± 0.13^d	7.40 ± 0.15^d	7.52 ± 0.43^b	7.45± 0.14^c	7.62± 0.15^{cd}

Each value is mean ± S.D of triplicate determinations.

Table 4. Sensory Evaluation of RTE Shrimp Crackers at Stored At Refrigerated Temperature(4^{0}C).

Storage Period (Months)	Appearance	Taste	Texture	Color	Odor	Overall Acceptability
0	8.08 ± 0.08^a	7.75 ± 0.19^a	7.67± 0.36^a	7.67± 0.66^a	7.67± 0.16^a	7.83 ± 0.16^a
2	8.05 ± 0.23^a	7.74± 0.11^a	7.63 ± 0.26^a	7.65 ± 0.34^a	7.63± 0.16^a	7.81 ± 0.21^a

4	8.01 ± 0.13^{b}	7.72± 0.36^{a}	7.60± 0.11^{ab}	7.63 ± 0.81^{a}	7.63± 0.16^{a}	7.80 ± 0.56^{a}
6	7.93 ± 0.03^{c}	7.70± 0.21^{ab}	7.57 ± 0.16^{b}	7.61± 0.45^{a}	7.60 ± 0.16^{a}	7.73 ± 0.19^{ab}
8	7.88 ± 0.11^{c}	7.65± 0.19^{b}	7.55± 0.16^{b}	7.60± 0.11^{ab}	7.60± 0.16^{a}	7.70 ± 0.37^{b}
10	7.82 ± 0.03^{cd}	7.53± 0.14^{c}	7.52± 0.16^{b}	7.57± 0.19^{b}	7.58± 0.16^{b}	7.70 ± 0.66^{b}
12	7.80 ± 0.03^{cd}	7.50± 0.10^{c}	7.50± 0.16^{b}	7.53± 0.16^{b}	7.56± 0.16^{b}	7.66 ± 0.56^{b}

Each value is mean ± S.D of triplicate determinations

DISCUSSION

Proximate analysis of foods is used to estimate the components in food and such food components includes moisture, ash, lipid, protein and carbohydrate content. These food components could be useful in the food industry for the development of new products, quality control or regulatory purposes(Thangaraj, 2016).

Protein :-The protein content of a food is considered the most essential constituent of food (Jeyasanta *et al.*,2019). Most seafood have protein content that range between 18-20%, (Balachandran,2001). These variations tend to occur based on age, fat content, spawning, and starvation of the raw materials.

The protein content of the ready-to-eat shrimp cracker found to be 5.22%, later declined to 5.07% at ambient temperature storage and to 5.09% at refrigerated temperature storage (4^{0}C). This could be attributed to gradual breakdown of initial crude protein to more volatile products(Eyo,2001)..

Lipid:- Lipid content of the ready-to-eat shrimp cracker was found to be 7.8%. At the end of storage at ambient storage conditions, the lipid content of the shrimp cracker had dropped to 7.45% and to 7.47% at refrigerated temperature storage. This could be attributed to the occurrence of oxidation of the lipids of the shrimp meat. Lipid oxidation has been reported to be is a major factor that triggers spoilage in seafood (Shikha *et al.*,2017).

Moisture:- Moisture plays an important role in slowing down the occurrence of bacterial induced spoilage in foods (Stansby,1967 Jeyasanta *et al* 2019). As an indicator of the susceptibility of a product to spoilage, it has been found to vary considerably depending on the lipid content of such food (Balachandran,2001).

Results of this present study indicated that the moisture content of this ready-to-eat shrimp cracker was found to be 5.93%. Jeyasanta *et al.* (2019) reported that the moisture content of three ready-to-eat shrimp products (Dry Prawn Pepper fry, Dry Prawn Sambal and Dry Prawn Masala) to be 3.5%, 5.08% and 5.1% respectively. The moisture content of ready-to-eat shrimp cracker in this study was found to less than 10%. This low moisture value (5.93%) makes this shrimp cracker less prone to microbial spoilage(Umoh and Odaoba,1999; Jeyasanta *et al.*,2019).It however, decreased to 5.75% at ambient temperature storage and 5.80% at refrigerated temperature storage. This could be attributed to occurrence of evaporation of moisture from the product at both storage conditions.

Ash :- Ash content of a food is the portion that remains after complete combustion of the product. It is constituted by the minerals present in seafood and the content varies between 0.4 and 2% in seafood (Balachandran,2001). Result of this study revealed that ash content in ready-to-eat shrimp cracker stored in ambient and refrigeration temperatures, increased gradually throughout the storage period from 4.7% to 5.15% at ambient storage temperature and to 5.17% at refrigerated storage temperature.. This outcome is supported by the findings of Shikha *et al*.,2017 who reported an increase in ash content of fish condiment prepared from Thai Pangus (*Pangasianodon hypophthalmus*) during storage at low temperature for a long period (12 months). This observed increased levels of ash content in the RTE product could be due to moisture loss in the shrimp cracker through evaporation (Kocatepe *et al*.,2011). Reports have indicated that ash increase is related to reduction in moisture content during storage(Pawar *et al*.,2013), even as this study also portrayed an inverse relationship between moisture content and ash content of the RTE shrimp cracker.

Sensory Evaluation

This deals scientific procedures involved in evoking, measuring, analyzing and interpreting reaction characteristics of food as perceived through the senses of sight, smell, taste, touch and hearing (Joseph, 2003). The acceptability of fishery product is usually based on the consumer's perception of the overall appearance, color, odor, taste and texture of the product. There were changes in all the sensory parameters during both ambient temperature storage and refrigerated temperature storage.

The organoleptic attributes in the RTE shrimp cracker in this study showed higher mean values at the beginning of the experiment at both ambient and refrigerated temperature storage compared to the values obtained towards the end of the experiment. This could imply a gradual decline in the quality attributes of the shrimp crackers. It could also be an indication of the fact that the longer the shrimp cracker is stored at both ambient and refrigeration temperatures, the gradual the decline in the nutritional quality of the product.

Conclusion

Findings of the study showed that the RTE shrimp cracker is a good source of protein, lipid and ash with little moisture content. Significant nutritional changes seemed to occur during the storage of the product at ambient and refrigeration temperatures. However, more decline in the nutritional qualities and organoleptic parameters seemed to occur in the RTE shrimp cracker stored at ambient temperature. Therefore consumers are advised to avoid long storage of the RTE shrimp cracker at ambient temperature and refrigerated temperature before consumption so as to ensure maximum freshness of the product.

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Isolation and Resistance Profiling of Streptococcus iniae from Pond Cultured *Clarias gariepinus*

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ABSTRACT

Streptococcus iniae is a significant fish pathogen of economic importance. Although, many studies have been done on Streptococcus iniae in other countries, no investigation has been carried out in Nigeria especially on Clarias gariepinus associated Streptococcus iniae infections. This study was aimed at identifying Streptococcus iniae from diseased pond-cultured Clarias gariepinus and to determine antibiotic resistance profile of the isolates. 150 diseased African Catfish were collected within a period of 12 weeks from eight consenting farms in Epe and Ikorodu farms, both in Lagos state of Nigeria. Samples were examined for signs of diseases at Aquaculture laboratory of Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos. Catfish specimens were aseptically taken from the kidney, liver, gills, skin and intestine of the affected fish samples, and analyzed microbiologically using various media. The physico-chemical parameters and microbiological analysis of the water samples from the fish ponds were determined. Confirmatory identification of Streptococcus iniae was carried out with previously described primers using multiplex PCR. Standard Kirby-Bauer disc diffusion method was used for antibiotic susceptibility test. Out of the 150 fish screened, 30 were presumptively identified as Streptococcus iniae. The total bacterial load for the water samples ranged between 2.1×10^6 *to* 3.2×10^7 *cfu/ml on Blood Agar Base and* 4.1×10^5 *to* 4.0×10^6 *cfu/ml on Nutrient Agar. The isolates were sensitive to Cefoxitin, Ciprofloxacin, Streptomycin and Gentamycin. All the isolates were resistant to Oxytetracycline, Pefloxacin, Ceftriaxone and Oxacillin. The lactate oxidase (lctO) gene specific for identification of S. iniae was recognized in 16 (53.3%) of the 30 suspected isolates. The presence of this bacteria could be a function of the level of hygiene of the culture system. However, the indiscriminate use of drugs in fish farming portends a significant hazard to public health.*

Keyword: *Streptococcus iniae*, *Clarias gariepinus*, Antibiotics, Lactate oxidase (*lct*O) gene, Multiplex PCR.

INTRODUCTION

Clarias gariepinus (Burchell, 1822) is a species of great economic importance in Africa and South-East Asia, especially as a food fish and vital in the local sustainability of the aquaculture enterprise. According to FAO, the intensive aquaculture system, with a recognized high production capacity, is becoming an important food producing industry (Pulkkinen *et al*., 2010). Fish reared in aquaculture facilities are susceptible to infectious diseases caused by bacterial pathogens (Sudheesh *et al*., 2012).

The β-haemolytic, Gram-positive coccus, *Streptococcus iniae*, is increasingly being recognized as an important fish pathogen all over the world, with outbreaks occurring in many different cultured species specifically, *Oncorhynchus mykiss, Seriola quinquerodiata, Siganus canaliculatus*, and *Tilapia spp*. (Klesius *et al*., 2006). Although, it was originally isolated from freshwater dolphins in 1958 (Pier and Madin, 1976), and the bacterium has been isolated from a wide spectrum of fish living in freshwater, estuarine and salt water, particularly from animals farmed in intensive culture conditions (Perera *et al*., 1997). The annual cost impact of its infection on the USA aquaculture industry in 1997, alone was estimated at 10 million US dollar (Suanyuk *et al*., 2010).

In Fish, *Streptococcus iniae* causes septicemia leading to a high prevalence of meningoencephalitis, myocarditis and choroiditis (Keirstead *et al*., 2014). Moreover, the bacterium has been identified as a potential zoonotic pathogen causing infections in humans involved in the handling and preparation of the infected fish (Elizabeth *et al*., 2013), indicating a threat to public health (Zlotkin *et al*., 2003). At least 25 cases of human infection by *Streptococcus iniae* had been confirmed to date (Lau *et al*., 2006).

Current convectional phenotypic identification methods for Streptococcus can easily identify opportunistic pathogens such as *Streptococcus pyogenes* and *Streptococcus agalactiae*. However, the unambiguous identification of some of the other species of Streptococci such as the viridans group Streptococci and *Streptococcus iniae* can be challenging. Thus, this study was carried out to investigate the occurrence of *Streptococcus iniae* from pond cultured African catfish and to as well profile their antibiotic resistance.

MATERIALS AND METHODS

Study Area

Epe and Ikorodu were selected as the study locations based on the aggregations of fish farms in both locations.

Sample Collection and Processing

Depending on availability of diseased fish, fish samples showing signs of disease such of erratic swimming behavior, weakness and fin hemorrhage were randomly collected from different culture pond over a period of twelve weeks from eight consenting farms from Epe and Ikorodu fish farm estate. Water samples were collected using sterile one-liter plastic containers and were transported on ice in a cooler box, Moribund diseased fish were collected in a clean sterile cooler containing ice pack. Sample analysis was performed at the Aquaculture Laboratory of Nigerian Institute for

Oceanography and Marine Research (NIOMR), Lagos. Fish samples were aseptically dissected using a sterile dissecting kit, and were examined for signs of disease. Specimen from the gills, skin, liver, kidney and intestine were obtained using sterile scalpel One gram of each sample was weighed and mixed with 9ml of 0.1% sterile peptone water ((LAB M Ltd, United Kingdom) and homogenized in a stomacher blender (Seward medical, United kingdom). Ten-fold serial dilutions of the homogenates were made and plated out.

Isolation, Enumeration and Identification of *Streptococcus iniae*

All the chemicals and reagent used are of analytical grade. All media were prepared according to manufacturer's instructions and sterilized by autoclaving at temperature of 121°C for 15 minutes. From the ten-fold serial dilutions of homogenates, 1ml aliquots of homogenates were plated in replicates on Blood agar base supplemented with 5% sheep blood and Nutrient agar medium, using pour plate method. The plates were incubated at temperature of 37^{oC} for 18 – 24hours. The total viable aerobic bacterial count was performed on Nutrient agar. Colonies were counted using Lapiz® digital colony counter (Mumbai, India) and expressed as Colony forming unit per gram of suspension (Cfu/ml). Discrete colonies were sub-cultured into freshly prepared Blood agar base plates supplemented with 5% sheep blood by streaking aseptically to obtain pure culture of the isolates. Pure cultures of bacterial organisms were identified using standard colony morphological responses, phenotypic, microscopic and series of biochemical procedures (Barrow and Feltham, 1993).

Water Quality Assessment

PONDLAB freshwater quality test kit (NT Laboratories Ltd, United Kingdom) was used to determine levels of nitrate, nitrite, ammonia, alkalinity, total hardness, dissolved carbon dioxide and iron while pH and temperature were determined using digital pH meter and thermometer (pHep by HANNA, Mauritius) and dissolved oxygen was determined using dissolved oxygen meter (EXTECH-DO600, Taiwan).

Antibiotic Sensitivity Test

Commercially available antimicrobial susceptibility Test Single Discs from Oxoid Ltd, Basingstoke, RG24 8PW, United Kingdom, was used. Pure bacteria colonies were pick from nutrient broth using a sterile wire loop and transferred to tubes each containing 5ml of sterile normal saline. The suspension was vortexed and adjusted to match 0.5 McFarland turbidity standards. Sterile swab stick was then dipped, rotated and pressed firmly on the tube walls above the culture to remove excess inoculums from the swabs. This was then evenly swabbed on the dried surface of Mueller-Hinton agar (Oxoid Ltd, England) plates ensuring even distribution of the bacterium. Ten different antimicrobial susceptibility single discs were placed on the bacteria plates using sterile forceps and were incubated at temperature of 37^{oC} for 18 to 24 hours, after which the diameter of zone of inhibition were measured with white transparent meter rule in millimeter. The methods describe above and the interpretations of results were done using standard recommended by Clinical Laboratory Standard Institute (CLSI, 2016). The ten antibiotics used have the following concentrations: Ciprofloxacin (5 µg), Vancomycin (30 µg), Cefoxitin (30 µg), Oxacillin (1 µg), Erythromycin (15 µg), Streptomycin (30 µg), Gentamycin (30 µg), Oxytetracycline (30 µg), Pefloxacin (10 µg), Ceftriaxone (25 µg).

Extraction of Genomic of DNA from *Streptococcus iniae*

The DNA was extracted using protocol of bacteria DNA extraction kit from Jena Bioscience Germany (Spin column based genomic DNA purification).

Multiplex Polymerase Chain Reaction (PCR) Amplification.

A multiplex PCR reaction was carried out using the Solis Biodyne 5X HOT FIREPol Blend Master mix. PCR was performed in 20 µl of a reaction mixture, and the reaction concentration was brought down from 5x concentration to 1X concentration containing 1X Blend Master mix buffer (Solis Biodyne), 2.0 mM $MgCl_2$, 200µM of each deoxynucleoside triphosphates (dNTP)(Solis Biodyne), 20pMol of each primer (BIOMERS, Germany), 2 unit of Hot FIREPol DNA polymerase (Solis Biodyne), Proofreading Enzyme, 5µl of the extracted DNA, and sterile distilled water was used to make up the reaction mixture. Thermal cycling was conducted in an Peltier thermal cycler PTC 100 (MJ Research Series) for an initial denaturation of 95°C for 5 minutes followed by 35 amplification cycles of 30 seconds at 95°C; 1 minute at 55°C and 1 minute 30 Seconds at 72°C. This was followed by a final extension step of 10 minutes at 72°C. The amplification product was separated on a 1.5% agarose gel and electrophoresis was carried out at 80V for 1 hour 30 minutes. After electrophoresis, DNA bands were visualized by ethidium bromide staining. 100bp DNA ladder was used as DNA molecular weight standard.

Table 1: Primer names, oligonucleotides sequences and their size of amplicons.

S/N	Primer Name	Oligonucleotide primer Sequence ($5^{'}$ - 3^{1})	Target gene	Annealing Temperature	Size of Amplicon in base pair (bp)
1	LOX-1	AAGGGGAAATCGCAAGTGCC	Lactate oxidase	55 °C	870
	LOX-2	ATATCTGATTGGGCCGTCTAA		55 °C	
2	F1	GAGTTTGATCATGGCTCAG	16S rRNA/IMOD	55 °C	220
	IMOD	ACCAACATGTGTTAATTACTC			

RESULTS

The microbiological analysis of water from the fish culture system revealed that the total bacterial load from the water samples ranged between 2.1×10^6 to 3.2×10^7 cfu/ml on Blood Agar Base supplemented with 5% sheep blood and 4.1×10^5 to 4.0×10^6 cfu/ml on Nutrient Agar. The physico-chemical parameters of water from Epe fish farm and Ikorodu fish farm was below acceptable standard. The value for nitrite, total ammonia, alkalinity, total hardness and carbon dioxide were also above the recommended standard range, and the pond water from Ikorodu fish farm E was acidic with a pH value of 5.9.

There were different signs of infection of the fish samples from different fish farms during the studies while some were asymptomatic showing little or no clinical signs. The signs include:

hemorrhage at the base of fin, exophthalmia (Pop eye), bloated abdomen, some fish exhibits darkening of the skin, petechial on the operculum, accumulation of fluid in the peritoneal cavity, necrosis of caudal fin, hemorrhaging of the internal organs, with pale livers, enlarged spleen and septicemia were also observed.

A total of 30 bacterial isolates with unique similarity in morphology and biochemical characteristics to the control strain of Streptococcus iniae were obtained from diseased fish. The lactate oxidase (*lct*O) gene specific for identification of *S. iniae* was recognized in 16 (53.3%) of the 30 suspected isolates (Figure 1a and 1b).

The antimicrobial susceptibility data generated revealed a moderate resistance of the *Streptococcus iniae* to the antibiotics used, as the isolates were susceptible to 5 out of 10 antibiotics used. Resistance to Oxytetracycline, Pefloxacin, Ceftriaxone, Oxacillin and Erythromycin were 100%, 100%, 100%, 100%, and 68.75% respectively while susceptibility of the isolates to Cefoxitin, Ciprofloxacin, Streptomycin, Gentamycin and Vancomycin were 100%, 100%, 93.75%, 100% and 31.25% respectively (Figure 2).

Table 2: Microbial Load of Water Samples from ponds where Diseased Catfish were collected.

		MEDIA	
LOCATION	FARM	BLOOD AGAR WITH 5% SHEEP BLOOD	NUTRIENT AGAR
EPE	Farm I	6.7 X 10^6 cfu/ml	4.1 X 10^5 cfu/ml
	Farm II	7.2 X 10^6 cfu/ml	5.3 X 10^5 cfu/ml
	Farm III	3.2 X 10^7 cfu/ml	4.0 X 10^6 cfu/ml
IKORODU	Farm A	2.4 X 10^7 cfu/ml	2.3 X 10^6 cfu/ml
	Farm B	4.3 X 10^6 cfu/ml	5.6 X 10^5 cfu/ml
	Farm C	2.1 X 10^6 cfu/ml	7.8 X 10^5 cfu/ml
	Farm D	5.1 X 10^6 cfu/ml	8.2 X 10^5 cfu/ml
	Farm E	3.5 X 10^6 cfu/ml	4.5 X 10^5 cfu/ml

Table 3: Physicochemical Parameters of Pond Water collected from the various farms

Location	Farm	Nitrate (mg/L)	Nitrite (mg/L)	Temp. (°C)	pH	DO (mg/L)	Iron (ppm)	TA (mg/L)	Alkalinity	CO_2 (mg/L)	TH	Period (week)
Epe	I	ND	ND	25	7.2	3	ND	ND	50	9	35	4
	II	ND	ND	27	7.0	2	ND	ND	48	7	49	4
	III	0.03	0.25	29.2	7.5	18	ND	0.1	276	21	107	4
Ikorodu	A	0.03	0.2	26	8.2	4.2	0.5	0.1	254	26	116	8
	B	0.02	ND	29.3	7.2	9.1	0.04	ND	64	8	70	8
	C	ND	0.03	29	6.5	7.6	0.03	0.01	36	10	75	8
	D	ND	0.03	26	6.0	8.0	ND	0.01	102	9	80	8
	E	0.02	ND	28.9	5.9	6.4	0.04	ND	85	6	55	8

Standard Value		0.1	< 0.1	25 to 30	6.5 to 8.5	≥ 5	<0.1	< 0.02	20 to 200	<15	20 to 100	Not applica

ND = Not detected, TA= Total Ammonia, DO = Dissolved Oxygen, TH = Total Hardness, ppm = part per million, CO_2 = carbon dioxide, mg/l = milligram per litre.

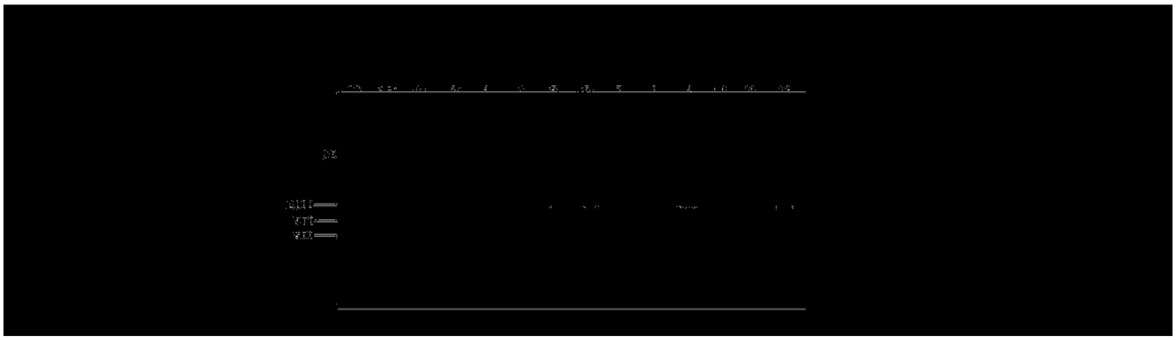

Figure 1a: PCR amplification of *Streptococcus iniae* lactate oxidase (lctO) gene at 870 base pair. The PCR products showed the DNA bands of predicted sizes of 870 bp, but no DNA band for 16S r RNA F1/IMOD at 220 bp

Lane M =Molecular DNA markers, lane –ve = Negative control (water), lane 1, 2, 4, 8, 10 = negative, lane 3, 5, 6, 7, 9, 11= *Streptococcus iniae* isolates, lane 12= *Streptococcus iniae* (control strain).

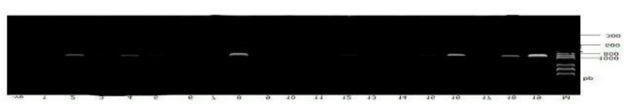

Figure 1b: Continuation of PCR identification of *Streptococcus iniae* lactate oxidase (lctO) gene from the remaining isolates.

Lane –ve = negative control (water), lane M = molecular DNA marker, Lane 2, 3, 4, 5, 8, 12, 15, 16, 18, 19 shows amplification of *Streptococcus iniae* lactate oxidase gene at 870 base pair, while lane 1, 6, 7, 9, 10, 11, 13, 14 and 17 were not amplified.

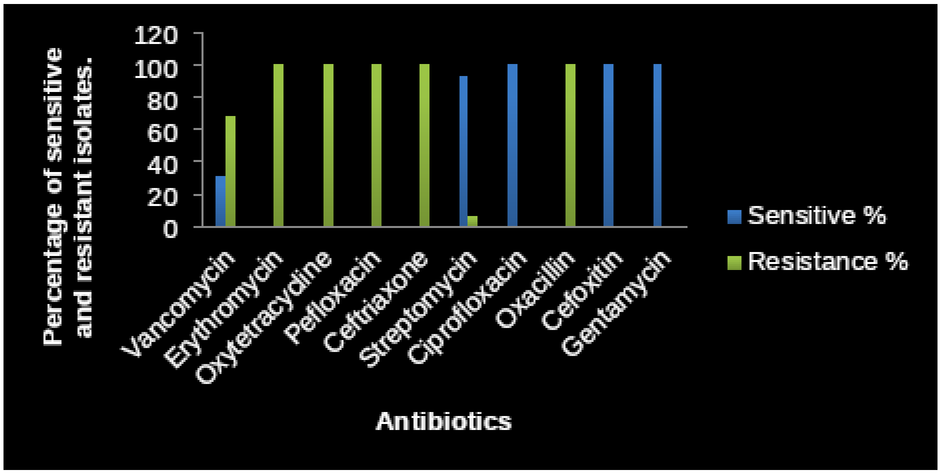

Figure 2: Antibiotic susceptibility patterns of the 16 *Streptococcus iniae* isolates.

DISCUSSION

The physico-chemical parameters from the fish culture system reveal abnormal water quality from Epe fish farm III and Ikorodu fish farm A, where the value for nitrite, total ammonia, alkalinity, total hardness and carbon dioxide were above the recommended standard range and acidic pH in Ikorodu fish farm E. These factors could be the link that predisposed the fish to stress which consequently resulted in disease presentation. Stress in aquatic organisms occurs from environmental or other factors that extend the fish physiological processes beyond the normal range. These series of physiological responses occurs in such a way that the fish try to adapt to stress through the use of its metabolic, ionic, hematological and structural components. Thus, if the duration or the severity of the stress exceeds the tolerance limits of the fish and it is unable to acclimatize, then adverse physiological effects will ensue and subsequently results in immunosuppression, decrease swimming performance, osmotic instability and thermal intolerance. The poor water quality of these farms could be the primary cause of mortalities observed with the bacterial infection.

The disease signs of streptococcal infection from this work were similar to those observed in infected Asian sea bass, except that necrosis of caudal fin and convulsion followed by quiescence was found (Wendy and Andrew, 2007). Though the farmers from Epe fish farm III and Ikorodu fish farm A when interviewed were complaining that those fish samples with no obvious signs frequently die without showing any signs of disease and it was a great concern to them as they continue to lose their investment on a daily basis with little or no knowledge of what was wrong with their fish. It was also observed that water samples from Ikorodu fish farm A and Epe fish farm III had higher bacterial load than those from other farms. Contamination of the water may be as a result of *Streptococcus iniae* being able to replicate in the intestinal tract of fish and be released into the water through faecal waste (Bromage and Owens, 1999; McNulty *et al*., 2003).

The naturally infected catfish reported in this study were from fish farms that produced the fish in an outdoor at a high density between 100,000 to 150,000 at 400grams – 1.2 kilograms in a borehole water volume of 40,000 liters without an adequate biofilter system. The average daily mortality was 25 fishes. The ecological factors, production conditions and epidemiology of *Streptococcus iniae* at the studied catfish farms were not similar to those reported at a Japanese flounder farm having an outbreak of *Streptococcus iniae* (Nguyen *et al*., 2002). A study by Perera *et al*. (1997) had shown that immersion of fish in water containing *Streptococcus iniae* and co-habitation with diseased fish (Shoemaker *et al*., 2000) have resulted in experimental infections. There-after, Bromage and Owens (2002) proposed that *Streptococcus iniae* infection occurred orally through the consumption of infected carrier fish or through the faecal-oral route. Furthermore, water-borne infection through nares (Evans *et al*., 2001), gills (McNulty *et al*., 2003) and through damaged skin, especially at higher fish stocking densities and challenge doses (Shoemaker *et al*., 2000), are among the most likely routes of transmission.

The antimicrobial susceptibility result revealed a moderate resistance of the isolates to the antibiotics tested especially to oxytetracycline. This is not in agreement with the works of other researchers elsewhere (Pier and Madin, 1976), as all 30 the isolates were resistant to Oxytetracycline but sensitive to Streptomycin. The rate of resistance to this antibiotic could be attributed to abuse and frequent use of Oxytetracycline for diseases prevention and growth promoter in fish farming in Nigeria. However, the multiplex PCR confirmed the presence of *Streptococcus iniae* in sixteen of the isolates. Previously, Mata and others provided evidence that the lactate oxidase (*lct*O) gene was limited to a few species of streptococci and related genera (Mata *et al*., 2004). This result indicates that the *lct*O gene should be an appropriate target molecule for specific *Streptococcus iniae* PCR assay since variation was observed in the biochemical profile of the isolates and the control strain. The primer combination LOX-1/LOX-2 gave a single amplification product of 870bp, which was specific for *Streptococcus iniae* identification.

The findings of this study suggest that pond cultured African Catfish (*Clarias gariepinus*) are susceptible to *Streptococcus iniae*. The occurrence and distribution of this bacterium highlight the significance of the organism as a major pathogen in the aquaculture industry. Although, many studies have been done on *S. iniae* in other countries (Rodkhum *et al*., 2012), no investigation has been carried out in Nigeria especially on *Clarias gariepinus* associated *S. iniae* infections. *Clarias gariepinus* farming is one of the fastest growing industries in Nigeria today. Consequently, there could be an outbreak of *S. iniae* infection in intensive *Clarias gariepinus* culture system in the nearest future in Nigeria. Hence, the results from this study will serve as a baseline data for proper diagnostic approach and treatment protocol of *S. iniae* infection in case of any eventuality. Therefore, the presence of this organism could be a function of the level of hygiene of the fish ponds. In addition, the indiscriminate use of antibiotics for aquaculture portends a significant hazard to public health. Consequently, the implementation of effective, long-term vaccination programs is the most likely target for future control of the potentially industry-limiting disease caused by *S. iniae*. Further research is however needed to fully understand this pathogen, principally its serological diversity and epidemiology before vaccination programs can become successful in a worldwide scale.

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Biochemical changes in *Tilapia guineensis* exposed to different concentrations of paraquat dichloride under laboratory conditions

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ABSTRACT
Biochemical changes in Tilapia guineensis exposed to Paraquat dichloride, at various concentrations of 0.00 (control), 0.50, 1.00, 1.50, 2.00 and 2.50 mg/L were carried out to determine the levels of alterations in fish exposed to this chemical. A total of 180 T.guineensis were used for the study. Blood samples were collected from the exposed fish and analyzed with Randox test kits. Results from the study indicated that the values of metabolites such as creatinine, total bilirubin and total protein reduced significantly ($p<0.05$) in the exposed fish when compared to the control values, while significant elevation ($p < 0.05$) was observed in urea. The antioxidants analysis showed that the values of superoxide dismutase (SOD) and Glutathione-s- transferase (GSH) reduced significantly ($p<0.05$) while Catalase (CAT) and Lipid peroxidase (LPO) increased in both sizes when compared to the control. Also the enzymes analysis showed that all the enzymes under consideration were significantly ($p<0.05$) elevated when compared to the control values. Moreover, the values of electrolytes such as Na^+ and K^+ ions significantly increased ($P < 0.05$) in the exposed fish when compared to the control values, while significant reduction ($p < 0.05$) of Ca^{2+} was equally observed in the treated fish and no significant difference ($p > 0.05$) in the values of Cl^- between the control and exposed fish. In conclusion, the chemical caused some changes in biochemical profiles of the exposed fish, predisposing them to renal-hepatic malfunctions which could be attributed to stress behavioral responses resulting from the toxicity of the chemical.

Keywords: Paraquat, Aquatic Environment, Fish, Toxicology, Biochemical profiles.

INTRODUCTION
Increasing amount of industrial, agricultural and domestic wastes into the aquatic environment has led to various degrees of harmful effects on the aquatic organisms (Baron *et al*., 2003). Pesticides applications have been on the rise in recent times to control pests on the farms. This ultimately, finds their way in to the aquatic environment (Akinrotimi and Gabriel, 2012). Typically the use of

pesticides has increased within the last few decades due to extensive use in agricultural and industrial processes; as such they are becoming threats to living organisms (Adonis *et al*., 2003). Contamination of aquatic environments by pesticides in turn leads to oxygen depletion; poisoning and resultant mass mortality of fishes. Fish has the tendency to accumulate toxicants from their environment using their various parts. Xenobiotics such as pesticides could lead to physiological dysfunction in various biological system, hematological index, behavioral response, biochemical, electrolytes alterations in fish (Gabriel *et al.*, 2012).
Paraquat dichloride has become one of the most used herbicide due to its distinctive mode of action, and is one of the few chemical options that can be used to prevent and mitigate problems with weeds that have become resistant to the very widely used non-selective herbicide (Correia *et al.*, 2007). Several authors have evaluated the effects of this chemical on fish, but the information on *T.guineensis* is limited, hence the need for this study. The present paper contributes to the assessment of toxicity and the effects of paraquat on some biochemical profiles of *T.guineensis*, euryhaline specie commonly found in the brackish water zone in Nigeria.

MATERIALS AND METHODS

Experimental Location and Fish

The study was carried out in African Regional Aquaculture Center, an outstation of Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria. One hundred and eighty *T.guineensis* (mean length 19.87±2.99 cm; mean weight 220.99±3.11g) were sourced from ponds during the low tide. The fishes were transported in six open 50L plastic containers to the laboratory and acclimated for a period of seven days.

Preparation of Test Solutions and Exposure of Fish

Samples of paraquat dichloride used in this experiment were purchased from a commercial outlet in Port Harcourt, Nigeria. *T.guineensis* were exposed to the chemical at the concentrations of 0.00 (control), 0.50, 1.00, 1.50, 2.00 and 2.50 mg/L in triplicates. Ten fish were randomly distributed into each test tank. The experiment lasted for a period of 15 days. The water in the tanks was renewed daily. The fish were fed twice daily at 5% body weight with a commercial feed.

Determination of Biochemical Profiles

At the end of each experimental period, 2ml of fresh blood sample was collected by making a caudal puncture with the help of fine needle and poured in heparinized sample bottles. Serum was separated by centrifugation at 10,000rpm for 5-8 minutes in TG20-WS Tabletop High Speed Laboratory Centrifuge. Serum electrolytes such as Na+, K+, Ca^{2+} and Cl^- were determined by using Hitachi 902 automatic analyzer (Japan), following the method described by Gabriel *et al* (2012). The metabolites such as Creatinine, Total Bilirubin, Total urea and Total protein were analyzed in conformity with the standard methods as described by APHA (1998). Enzymes and anti-oxidants in the blood of the exposed *T.guineensis* were analyzed using a universal microplate reader on a Jenway visible spectrophotometer (Model 6405).

Statistical Analysis

All the data were expressed as mean and standard deviation of mean. The statistical package, SPSS Version 22 was used for the data analysis. The means were separated using two-way ANOVA and the two means were considered significant at 5 % ($p<0.05$).

RESULTS

The resultant effects of paraquat dichloride on the electrolytes in the plasma of *T.guineensis* are presented in Table 1. It was observed that sodium ion (Na^+) and K^+ increased with increasing concentrations of the pesticides. Also Ca^{2+} decreased significantly when compared to the control values while Cl^- were within the range of 13.0- 16.0. The effects of paraquat dichloride on the metabolites in the serum of *T.guineensis* are presented in Table 2. It was observed that creatinine, total protein and total bilurubin decreased with increasing concentrations of the herbicide while urea increased significantly when compared to the control values. The effects of paraquat on the enzymes in the serum of *T.guineensis* are presented in Table 3. It was observed that the values of AST, ALT, ACP, ALP and LDH increased with increasing concentrations of the chemical. The effects of paraquat dichloride on the antioxidants in the serum of *T.guineensis* juveniles are presented in Table 4. It was observed that the values of SOD and GSH decreased with increasing concentrations of the herbicide while CAT and LPO increased significantly when compared to the control values.

Table 1: Concentration of Electrolytes ions in *T. guineensis* Exposed to Paraquat Dichloride (Mean±SD)

Concentration (mg/L)	Na^+	Ca^{2+}	K^+	Cl^-
0.00	40.30 ± 1.01[a]	38.88 ± 2.09[e]	2.40 ± 0.99[a]	13.00 ± 1.02[a]
0.50	44.50 ± 2.02[a]	25.02 ± 2.19[d]	3.80 ± 1.03[a]	14.00 ± 1.04[a]
1.00	50.80 ± 1.20[b]	22.77 ± 1.45[c]	5.50 ± 0.02[b]	15.00 ± 1.99[a]
1.50	60.90 ± 1.02[c]	18.04 ± 2.09[c]	7.10 ± 0.01[b]	16.00 ± 1.19[a]
2.00	65.50 ± 1.54[c]	14.50 ± 1.04[b]	10.03 ± 0.04[c]	15.00 ± 2.02[a]
2.50	70.99 ± 2.01[d]	8.56 ± 1.08[a]	11.20 ± 0.18[c]	15.00 ± 1.01[a]

Means in the same column with different superscripts are significantly different ($p<0.05$)

Table 2: Metabolite activities in *T. guineensis* exposed to Paraquat Dichloride

Concentration(mg/L)	Creatinine	Urea	Total bilirubin	Total protein
0.00	90.00±5.00[c]	5.00±0.00[a]	21.33±1.15[b]	35.10±1.00[c]
0.05	83.33±5.77[b]	5.00±0.00[a]	20.00±1.00[b]	26.00±5.56[b]
0.10	76.60±5.77[a]	6.33±0.57[b]	16.66±1.52[a]	27.66±6.65[b]
0.15	65.00±5.00[b]	5.33±1.15[a]	17.66±0.57[a]	23.66±3.21[b]
0.20	60.00±10.00[a]	7.33±2.08[c]	14.66±0.57[a]	19.00±1.00[a]
0.25	48.30±2.88[a]	11.00±0.00[c]	18.33±1.15[a]	28.00±1.00[b]

Means within the same row with different super scripts are significantly different ($P<0.05$)

Table 3: Enzymes Activities in *T. guineensis* Exposed to Paraquat Dichloride

Concentration	Enzymes (IU/L)				
	AST	ALT	ACP	ALP	LDH
0.00	71.24±1.87[a]	55.00±1.00[a]	20.65±0.99[b]	63.33±3.05[a]	300.66±11.06[a]

0.05	81.65±6.68^{b}	58.66±1.52^{a}	17.90±1.29^{a}	68.66±5.68^{a}	334.66±8.08^{a}
0.10	80.89±2.80^{b}	69.33±1.52^{b}	22.33±1.98^{b}	77.00±3.60^{b}	361.66±4.72^{b}
0.15	86.73±1.57^{b}	57.00±11.35^{a}	27.99±2.00^{b}	75.66±0.57^{b}	364.33±4.02^{b}
0.20	88.98±3.65^{b}	71.00±1.73^{c}	34.24±1.61^{c}	74.00±1.00^{b}	375.33±5.03^{b}
0.25	86.40±3.47^{b}	65.66±1.15^{b}	26.94±1.05^{b}	83.33±1.52^{c}	389.66±9.60^{b}

Means within the same row with different super scripts are significantly different ($P<0.05$)
AST: Aspartate transaminase , ALT: Alanine transaminase, ACP: Acid phosphatase, ALP: Alkaline phosphatase and LDH: Lactate dehydrogenase

Table 4: Antioxidants Levels in *T. guineensis* Exposed to Paraquat Dichloride

Concentration	**CAT**	**GSH**	**SOD**	**LPO**
0.00	80.00±2.98^{a}	7.66±0.57^{a}	15.33±0.57^{a}	12.66±1.15^{a}
0.05	85.00±7.05^{a}	7.33±1.15^{a}	14.33±0.44^{a}	13.66±0.57^{a}
0.10	91.68±7.93^{a}	5.33±9.57^{a}	11.33±0.51^{a}	18.66±1.52^{a}
0.15	97.87±6.90^{a}	5.00±1.00^{a}	11.33±0.57^{a}	17.00±1.00^{a}
0.20	99.00±5.87^{a}	5.00±0.00^{a}	10.33±0.52^{a}	19.66±0.57^{a}
0.25	112.85±9.98^{a}	5.66±0.57^{a}	11.33±0.09^{a}	14.33±1.54^{a}

Means within the same row with different super scripts are significantly different ($p<0.05$)
CAT: Catalase, GSH: Glutathione-S-Transferase, SOD: Superoxide dismutase and LPO: Lipid peroxidase

DISCUSSION

Electrolytes are needed for osmo-regulatory purposes in the body system of living organisms; therefore, alterations of the electrolyte balance of an organism would adversely affect the organism. A slight variation of values in this present study is an indication that the pesticides affected the *T.guineensis* electrolytes system in the tissue. According to Nte and Akinrotimi (2011) slight change in values of electrolytes can disturb osmotic and ionic regulation in fishes as well as general physiology in the fish. Slight fluctuation in sodium ($Na+$) values was also reported by Awoyinka *et al.*(2011) when they exposed *Clarias anguilaris* to crude oil.
ALT, AST, ALP are non-plasma specific enzymes that are localized in tissue cells of liver, heart, gills, kidneys, muscles and other organs and their presence in the blood may give specific information about organ dysfunction. Variations in the activity of these enzymes resulting from toxicant or contaminant effects in various organs of fish have been observed in other species by different authors (Gabriel *et al.*, 2012). In this study, activities of these enzymes increased, as the concentration of paraquat increased in the serum of *T.guineensis*. This assertion corroborated the findings of Gabriel *et al*. (2012) in *C. gariepinus* exposed to cypermethrin. These authors opined that the increase of transferases is as a result of diversion of alpha-amino acids in the tricarboxylic acid (TCA) cycle as keto-acids to augment energy production.

The decrease values of GSH observed in this study may be due to either direct scavenging of radicals or increased peroxidase activity (Simonata *et al*., 2008). In present study, SOD and GSH was suppressed by paraquat exposure in *T.guineensis* when compared to the control fish. Decreased SOD levels in the plasma of treated fish in this study indicate decreased ability of the tissues to handle O_{2-} free radicals. Similar findings on decreased SOD have been reported in the tissues of *Oreochromis niloticus* exposed to heavy metals intake (Firat and Kargin, 2010). The present study revealed that CAT activities in the plasma of *T.guineensis* exposed to paraquat increased significantly ($P<0.05$) after 15 days of exposure. The elevation of CAT in the present study may be physiological adaptation for the elimination of ROS generation. Similar results have been observed in Tilapia (*O.niloticus*) exposed to pesticides in the laboratory (Durmaz et al., 2006). In the present study, lipid peroxidase increased significantly in the plasma of *T.guineensis* after 15 days of exposure. The elevation of lipid peroxidation in the study, suggested participation of free radical induced oxidative cell injury in mediating the toxicity of paraquat.

In this study, total protein, creatinine and total bilurubin in the plasma of the exposed fish decreased with increased concentration of paraquat dichloride while urea increased considerably when compared to the control values. Inyang *et al.* (2016) reported similar results in plasma total protein, albumin, glucose and organ's total urea and creatinine of *Clarias gariepinus* exposed to diazinon. Similarly, Ben-Eledo et al. (2017), observed that exposure of fish for a long time to most toxicants including pesticides interferes with protein metabolism, depletion of total protein in the plasma and serum of fish. The decrease in total protein and creatinine levels may be due to impaired synthesis of protein or enhanced loss of protein via excretion and is also suggestive of some problem in the kidney (Gabriel and George, 2005). However, the very low levels of total bilirubin recorded in this study suggest that the liver may not have been affected by the toxicant. An increase in urea suggested that the kidney may have been affected by the toxicant. According to Kori-Siakpere *et al.*(2007), the ability of the kidney to excrete these products might further indicate an increase in glomerular filtration rate in the exposed fishes. Additionally, increase in values of these metabolites may suggest that the kidney is under stress to remove these metabolic wastes due to toxic effect of paraquat.

CONCLUSION

This study also showed that the toxicants caused significant alterations in biochemical profiles of the exposed *T.guineensis*, a clear indication that their usage in the fields and water environment may be a threat to aquatic biota.

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Temporal and spatial composition, abundance and distribution of macro-invertebrate fauna in a South-West lagoon in Nigeria

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ABSTRACT

Macro-invertebrates play an important role the ecosystem as food and also as bio-indicators of pollution due to their sensitivity to toxic compounds in the environment. a longitudinal survey of the macro-invertebrate fauna of yewa lagoon south-west nigeria was studied for a period of two years (april 2017-march 2019). Kick sampling method and van veen grab were used for sample collection from seven stations. a total of 40 species were identified belonging to 3 phyla: mollusca, arthropoda and annelida. The macro-invertebrates were dominated numerically by gastropoda (63.11%) followed by insecta (19.50%) and the least was bivalvia which contributed 0.01%. spatially, iyafin (25.3%) had the highest number of macro-invertebrates followed by ibawe (17.54%), while the least abundance was recorded at ere (9.43%). gastropoda had highest abundance at iyafin (86.9%) and least abundance at yewa river entrance (41.5%), while the sub-dominant group, insecta was the highest at yewa river entrance (41.7%). Seasonally, gastropoda was also the highest (43.15%) in abundance during the wet season followed by insecta (11.34%); the trend was the same in the dry season although the wet season had higher significant abundance. the abundance, distribution and composition of macro-invertebrate fauna of yewa lagoon were influenced by seasons.

Keywords: macro-invertebrate, Temporal abundance, Spatial distribution.

INTRODUCTION

Macro-invertebrates are important components of the aquatic ecosystem. They serve as food to some aquatic organisms especially fishes, and is a source of protein to humans directly and indirectly; they play important roles in energy flows, nutrient cycling and maintaining community balances in the ecosystems Idowu and Ugwumba (2005). Due to their limited movement, inability to avoid pollutant and sensitivity to toxic compounds, they are used as indicators and environmental monitors because they make contact with water column as well as sediments or substrates. The variations in abiotic factors always affect the macro-invertebrate in different ways and could be expressed as changes in reproduction, growth rate, mortality, distribution, diversity and abundance of these organisms in a given ecosystem (Ajao and Fagade 1990). The importance of macro-invertebrates in a given ecosystem cannot be over emphasized; so the need for quantitative as well as qualitative study to ensure sustainability of aquatic resources towards food security is of utmost importance.

Yewa Lagoon have recorded some scientific research which include the works of Olopade and Taiwo (2008) on the fish fauna of Yewa Lagoon. Taiwo and Olopade (2020) studied the fecundity and condition of *Chryschthys nigrodigitatus* and Taiwo *et al.* (2015) worked on heavy metals in the water, sediments and fish in Yewa Lagoon. Bamidele *et al.* (2015) studied the diversity of Tilapia in Yewa Lagoon. Effiong and Inyang (2015) worked on the epiphytic algae on aquatic macrophyte in Yewa Lagoon and their possible use as indicator. Effiong and Inyang (2016) studied diversity of phytoplankton in Iragbo part of Yewa Lagoon. Yewa Lagoon is a freshwater lagoon located in the western side of Lagos which lies approximately within latitudes $6^0 22'$ to $6^0 36'$ North and longitudes 2^0 50′ to 2^0 54′ East of the Greenwich Meridian. The lagoon has a total catchment area of approximately 5000 km^2 within the West African tropical climate (Lawson and Oloko, 2013). Yewa Lagoon is well known for some anthropogenic activities which include domestic chores (like bathing, and washing) logging, sand mining, boat transportation, fishing etc. The dearth of information on macro-invertebrate fauna of Yewa Lagoon motivated this research work as part of its biodiversity. The present study is focused on the abundance, distribution and species composition of macro-invertebrates of Yewa Lagoon which will contribute to the bio-data of the lagoon for research, policy making and conservation of its resources.

MATERIALS AND METHODS

Yewa Lagoon is a freshwater body located in the western side of Lagos which lies approximately within latitudes $6^0 22'$ to $6^0 36'$ North and longitudes 2^0 50′ to 2^0 54′ East of the Greenwich Meridian. Yewa River is the major sources of water to Yewa Lagoon, while it is drained by Port Novo Creek (Benin Republic) and Badagry Creek (Nigeria) in the south which empties into the Atlantic Ocean via Lagos Harboùr (Figure 1) The major activities in the lagoon include logging, sand mining, boat transportation and fishing. Yewa Lagoon is characterized by several plants like sedges (*Cyperu sarticulatus*, *C. papyrus*, and *Paspalum vaginatum*); ferns (*Achrosticum sp*, *Marsilea sp*, *Cyclosorus sp*, and Ceratopleris sp), water hyacinth (*Eichhornia crasipes*), water lettuce (*Pistia stratioles*), duck weeds (*Lemna sp)* and palms (*Pandanus candelabrum*, *Raphia hookeri*, and *Phoenix reclinata*). Seven sample stations were selected using a GPS and named after the villages closer to it as follows: Iyafin, Afowo, Ibawe, Itohun, Iragbo, Ere and Yewa River entrance.

A longitudinal survey using a random sampling design was carried out in Yewa Lagoon for a period of two years. Macro-invertebrate samples were collected monthly from all stations using kick sampling method and a grab (Van Veen) sample of the sediment was also collected for benthic macro-invertebrate, the sediment collected was sieved through a 0.5mm mesh sieve in order to reduce the bulk of material (Edward and Ugwumba 2011). The organisms were sorted out and preserved in 10% formalin to which Rose Bengal stain was added (Williams *et al.* 1999; Andem *et al.* 2012) in well labeled plastic containers and transported to the laboratory for further studies. In the laboratory, preserved samples were poured unto a white tray and sorted out and all animals in the sample were picked up with the help of a blunt forceps and magnifying lens. Macro-invertebrates were identified using relevant identification guides by Dance (1974), Morton (1971), Margo and Branch (1978), Pennak (1978) APHA/AWWA/WPCF (1985), Brown (1994), Yankson and Kendall (2001). Each identified species was counted and recorded accordingly. Macro-invertebrate data were subjected to descriptive statistics using excel for windows.

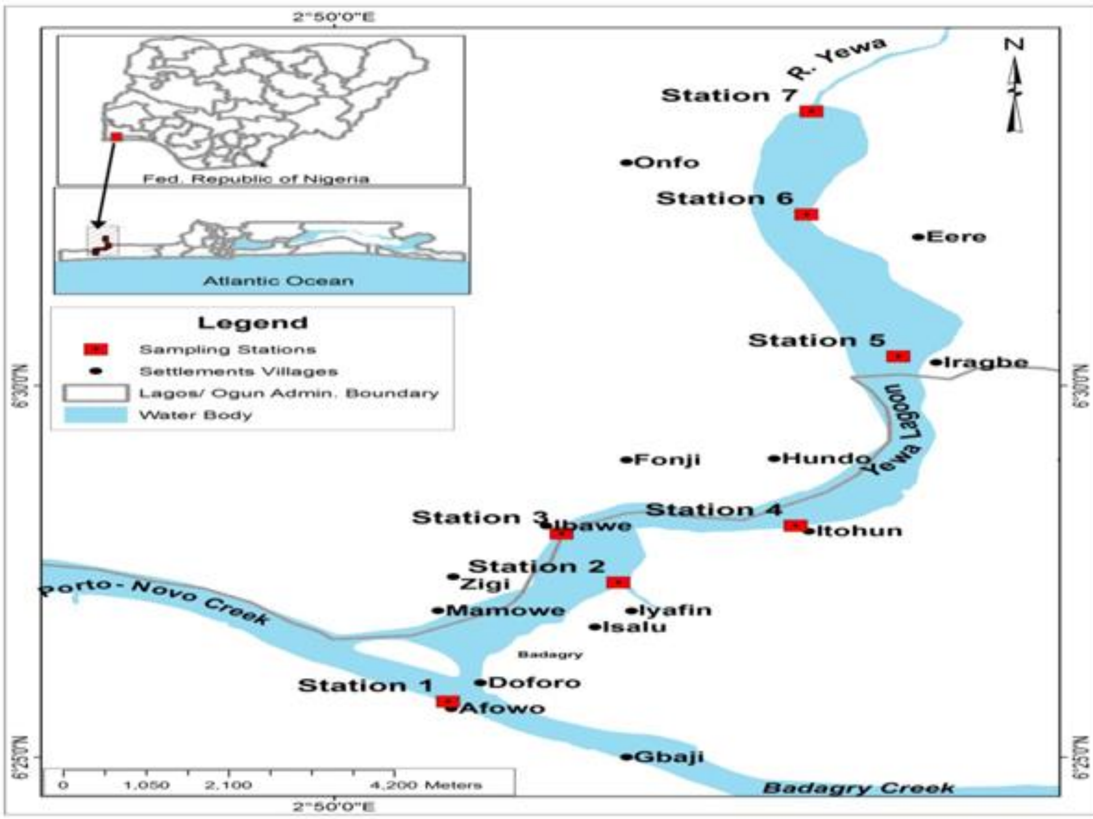

Figure 1. Map of Yewa Lagoon showing the sampling stations

RESULTS

Forty macro-invertebrate species were identified and was dominated by the Gastropoda comprising seventeen species, they constituted 63.11% of the total number of macro-invertebrates. *Pachymelania bryonensis* had the highest percentage composition (16.52%) followed by *P. fusca* (12.96%). The least abundant gastropod was *Neritina glabrata* and *Pseudosuccinea columella* which made up about 0.01% each of the total number of macro-invertebrate. The insect group was the subdominant and contributed 19.50% to the total macro-invertebrate abundance. *Dineatus sp* was the most abundant insect (7.90%), followed by *Hemicordulia* sp (5.80%) and the least abundant (0.01%) was recorded for *Aquarius remigis* and *Tipula sp*. Amongst the arthropods, Decapoda was the most dominant, with four species which constituted 11.19% of the total macro-invertebrate abundance by number. *Penaeus* sp had the highest abundance (9.89%) while *Diogenes pugilator* was the least (0.01%) abundant (Table 1). Bivalvia was the least in abundance and contributed 0.01% to the total number of macro-invertebrate during the study period (Table 1).

The trends of variations in the monthly abundance of macro-invertebrates was illustrated in Figure 2. Gastropods was higher in the wet season month of May 2017 and relatively lower in the dry season but had the least abundance in October 2017. The highest Insecta was recorded in the month of February 2018 and the lowest in the month of November 2017. The least group Bivalvia was recorded for only March 2018. Macro-invertebrate abundance was significantly higher in the wet season with Gastropoda as the highest followed by the Insect while the Bivalvia recorded the least abundance (Figure 3)

Spatially in the wet season, Gastropods were also the most abundant macro-invertebrate numerically (Figure 4). They constituted the highest percentage abundance (86.9%) at Iyafin and least (41.5%) at Yewa River Entrance. The subdominant group insecta were highest at Yewa River Entrance and lowest at Iyafin. The Decapoda had the highest (18.75%) composition by number at Afowo and least (6.51%) at Iyafin. Amphipoda had their highest composition by number (9.38 %) at Afowo and the least (2.98%) at Iyafin. Arachnida recorded the highest abundance (0.75%) at Itohun and the least (0.10%) at Afowo and Ibawe and was not found at Iyafin, Ere and Yewa River Entrance (Figure 4). During the dry season, Gastropoda took the lead with highest abundance (75.2%) at Iyafin and the lowest at Yewa River Entrance. Insecta recorded its peak abundance (60.9%) at Yewa River Entrance and lowest (13.1%) at Iyafin. Decapoda recorded highest (15.9%) at Afowo and the least (4.9%) at Iragbo. Amphipoda was highest (9.1%) at Itohun and lowest (4.4%) at Ere. Polychaete recorded the highest value (1.1%) at Ibawe and the least value (0.31%) at Afowo. Bivalvia was recorded only in the dry season with percentage composition of 0.18% at Ibawe station. Isopoda were recorded (0.37%) at Ibawe (Figure 5).

Generally, Iyafin had the highest percentage abundance of all the macro-invertebrate encountered throughout the study period. Ere station recorded the least in abundance in the combined seasons; however, Itohun recorded the least abundance during the wet season and Yewa River entrance had the least during the dry season (Figure 6).

Table 1. Checklist of Macro-invertebrate in Yewa Lagoon during the study period

Phylum	Order	Species	Wet season	Dry Season	Overall
Mollusca	Gastropoda	*Pachymelania bryonensis*	16.80	15.99	16.52
		Pachymeania fusca	13.01	12.86	12.96
		Eussoia oblonga	10.29	7.06	9.19
		Melanoides tubaculata	7.28	9.30	7.97
		Burnupia sp	9.75	2.51	7.29
		Potamopyrgus ciliatus	2.60	3.56	2.93
		Eussoia inopina	1.22	4.41	2.31
		Gabbiella sp	1.90	0.81	1.53
		Neritina natalensis	0.65	0.71	0.67
		Ferrissia sp	0.80	0.00	0.53

		Bulinus globosus	0.68	0.07	0.47
		Physa acuta	0.05	0.78	0.30
		Marisa cornuarletis	0.03	0.48	0.18
		Potadoma moerchi	0.28	0.00	0.18
		Afrogyrus sp	0.00	0.14	0.05
		Neritina glabrata	0.00	0.03	0.01
		Pseudosuccinea columella	0.00	0.03	0.01
	Bivalvia	*Cerastoderma edule*	0.00	0.03	0.01
Arthropoda	Decapoda	*Penaeus sp*	10.65	8.42	9.89
		Sesarma huzardii	1.15	1.22	1.18
		Callinectes amnicola	0.10	0.10	0.10
		Diogenes pugilator	0.02	0.00	0.01
	Amphipoda	*Gammarus roeselli*	5.31	6.92	5.86
	Isopoda	*Exocirolana sp*	0.05	0.07	0.06
	Insecta	*Dineutus sp*	7.51	8.66	7.90
		Hemicordulia sp	4.28	8.76	5.80
		Chironomous transvalensis	0.98	3.19	1.73
		Stenonema sp	1.29	2.31	1.64
		Gyrinus natator	1.31	0.10	0.90
		Stenelmis sp	1.12	0.44	0.89
		Lonchoptera sp	0.28	0.14	0.23
		Appasus sp	0.31	0.27	0.30
		Psephenus sp	0.03	0.14	0.07
		Gerris lacustris	0.03	0.00	0.02
		Aquarius remigis	0.02	0.00	0.01
		Tipula sp	0.00	0.03	0.01
	Arachnida	*Argyroneta aquatica*	0.17	0.07	0.14
Annelida	Polychaeta	*Hirudo medicinalis*	0.00	0.07	0.02
		Lumbriculus sp	0.02	0.00	0.01

Polyopthalmus pictus	0.00	0.31	0.10

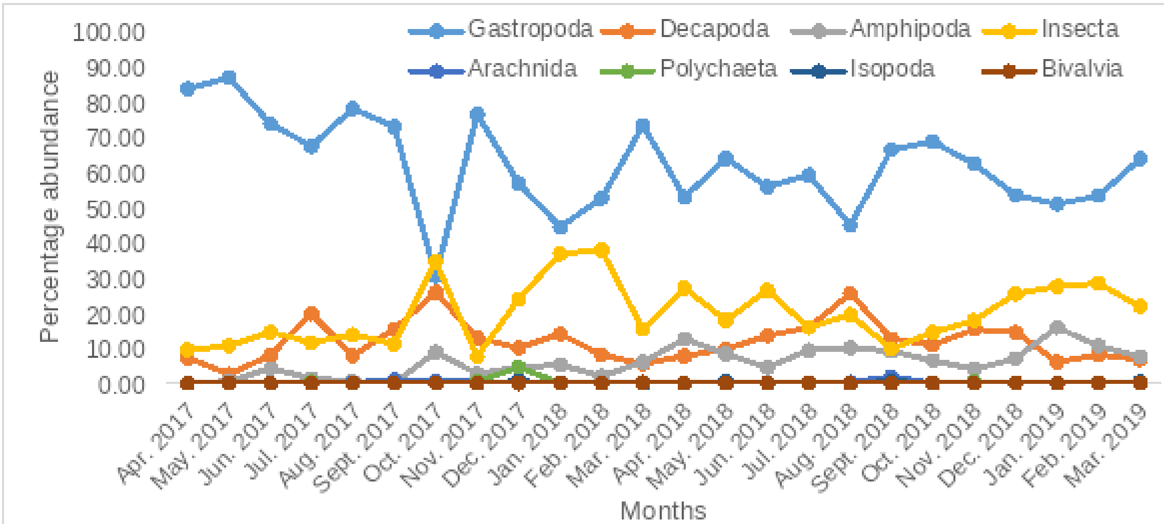

Figure 2. Monthly variation of major macro-invertebrate in Yewa Lagoon during the study periods.

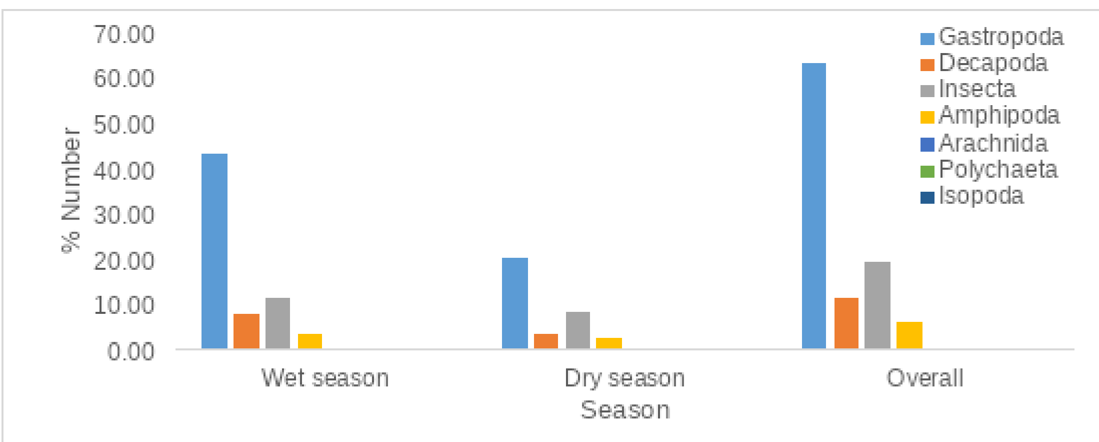

Figure 3. Relative abundance by number of Macro-invertebrates in Yewa Lagoon

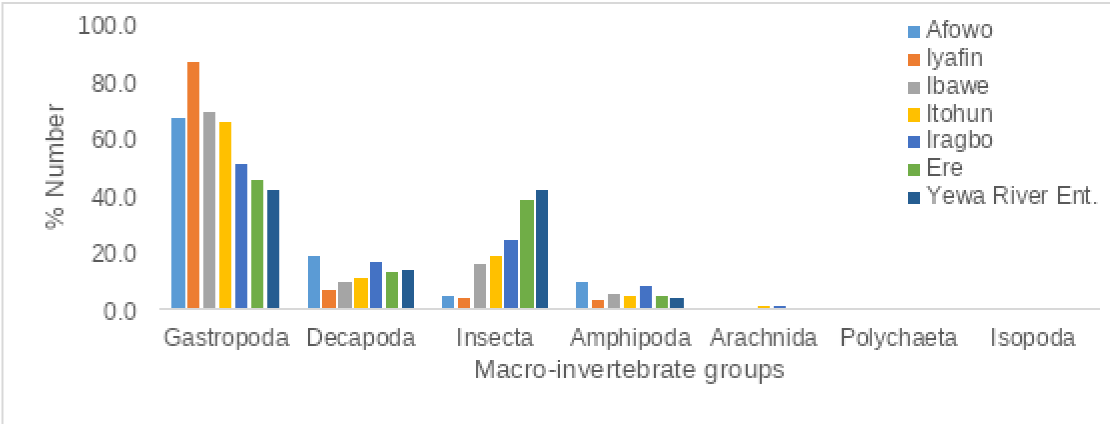

Figure 4: Spatial Percentage abundance of macro-invertebrates during the wet season

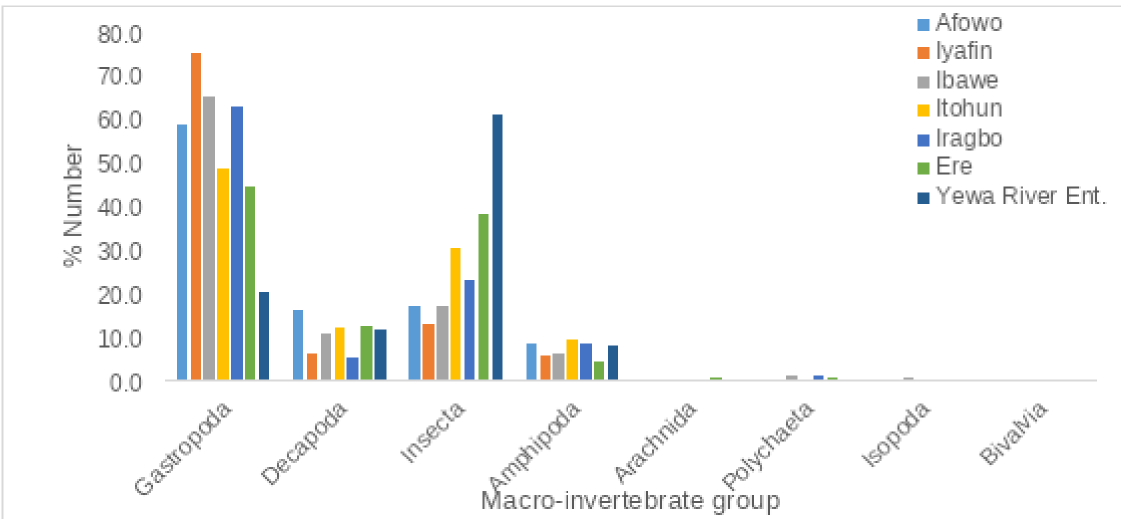

Figure 5: Spatial Percentage abundance of macro-invertebrates during the dry season

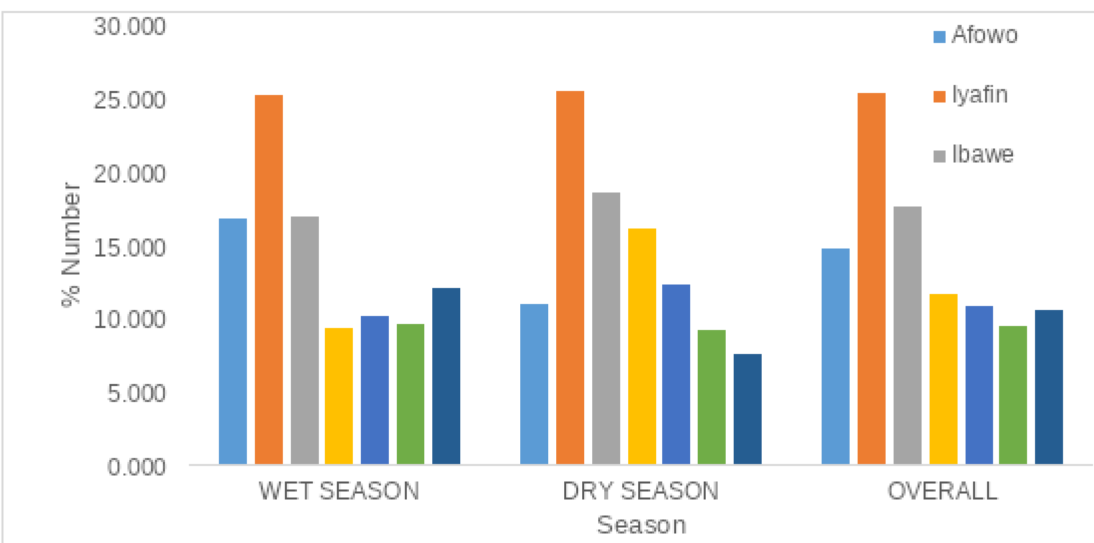

Figure 6. Spatial and seasonal abundance by number of macro-invertebrate during the period of study

DISCUSSION

The variations in the abundance, species composition and distribution of macro-invertebrates could be largely attributed to changes in the physico-chemical parameters, nature of substrate, seasons, macrophytes vegetation, predator-prey relationship as well as anthropogenic activities especially sand mining and sand filling which destroys the habitat. Yewa Lagoon will be classified as fairly rich in species composition as forty species of macro-invertebrate were encountered in this study. Similar numbers had been reported in different water bodies, Omoigberale and Ogbeibu (2010) recorded 51 species for Osse River, Ajao and Fagade (1990 and 2002) reported 42 species for Lagos Lagoon, Olomukoro and Ezemonye (2007) recorded 55 taxa of macro-invertebrates in Edo state, Ezemonye *et. al*. (2004) reported 51 taxa from Warri and Frocados Rivers in Delta state. The forty species of macro-invertebrate encountered in this present study far exceeded what had been reported in some other water bodies in the tropics (George *et al*. 2010; Sharma *et. al*. 2011, Edward and Ugwumba 2011, Andem *et.al*. 2012, Adedeji *et.al.* 2012). The most important fish species (*C. nigrodigitatus*) of Yewa Lagoon feed mainly on the gastropods as it's readily available as food sources. Ajao and Fagade (2002) considered physical variability, depths of investigation, prevailing ecological conditions, state of contamination as important factors influencing the species composition and abundance of macro-invertebrates in Lagos Lagoon.

Gastropoda is the most abundant group of macro-invertabrates in Yewa Lagoon. Their high abundance may be attributed to availability of macrophytes and suitable sediment type in the water which serves as habitat and nursery ground for them. Umeozor (1995) as well as Edward and Ugwumba (2011) reported that the most important factors causing variation in occurrence and abundance are physico-chemical qualities, nature of immediate substrate and availability of food. However, the molluscs (gastropods) and Arthropoda (insects) that dominated the macro-invertebrate population of Yewa Lagoon had been reported to be relatively tolerant of physico-chemical variations in the environment and widely distributed irrespective of seasons (Ormerod, 1988; Ajao and Fagade, 2002; Omoigberale and Ogbeibu, 2010; Sharma *et. al.,* 2011, Edward and Ugwumba 2011). Gastropod molluscs had been documented as the most dominant macro-invertebrate (Ajao and Fagade, 2002; Adedeji *et. al*., 2011, Edward and Ugwumba 2011). Molluscs are very important in the decomposition of plant matters and other detritus which forms the basis of many food chains. The most abundant gastropods in Yewa Lagoon is *Pachymelania bryonensis* followed by *P. fusca* serving as direct shell fish food for human consumption. The success of gastropods in Yewa Lagoon could be attributed to favourable physico-chemistry, food availability, suitable substrates for attachment and ability to stand fluctuation in water quality and habitat structure.

The sub-dominant group arthropoda of which Insecta ranked first in abundance and widely distributed, as they occurred throughout the sampled period, may be attributed to the abundance of macrophytes as habitat. Avoaja *et al*. 2007 reported arthropod as the most dominant group in a humid tropical zone water reservoir. The least group of macro-invertebrate in both abundance and species composition was the Bivalvia and their low abundance could be attributed to unfavourable physico-chemistry as well as unstable habitat structure. George *et al.* 2010 reported polychaete as the most dominant macroinvertebrate in Okpaka creek sediment and attributed their success to high level of pollution tolerance.

Spatially, gastropods recorded highest abundance at Iyafin station and this may be as a result of suitable substrate and observed low energy of transport of the sediment which allows them to settle there without being washed away by current or wave actions. The abundance of decapods at Yewa River entrance and may be attributed to high macrophytes and organic matter recorded while the least was recorded at Iyafin. Habitat preference is one of the factors responsible for low abundance or total disappearance of some organisms in an area as observed by Edward and Ugwumba (2011) in Egbe Reservoir. Pollution tolerant groups like dipteran and polychaete were high in Ibawe station and their success may be attributed to the nature of sediment substrate and resistance to pollution caused by anthropogenic activities. Dipterans like *Chironomus sp* are known as pollution indicator and burrow in soft sediments. Their usage as pollution indicators was documented by Williams and Feltmate (1992); Tan and Beh (2016). The disappearance of some macro-invertebrates in some stations could be as a result of the unfavourable habitat, nature of substrate, lack of the preferred food item as well as prevailing water quality and pollution status.

The higher abundance recorded in wet season in the present study conforms with the report of Edward and Ugwumba (2011). The result of this present study is not in agreement with the reports of Ajao and Fagade (2002), Omoigberale and Ogbeibu (2010), Ibemenuga and Iyang (2006), Sharma *et. al*. (2011), George *et al*. (2010) as they recorded higher abundance in the dry season and attributed the low density in the wet season to unstable substrate caused by rain. The high abundance reported in this work during the wet season could be attributed to increase in macrophytes, availability of food materials, and increased depth of water body (which makes it difficult for predators to locate them). According to Edward and Ugwumba (2011) other factors which may account for the increased abundance during the wet season is that predators like aquatic birds and some fishes exploit invertebrate prey better in the dry season as a result of the reduced water level, and clearer water that makes it easier to locate their prey.

Ogbeibu (2001) attributed the success of a particular organism in a given environment as a reflection of its heterogeneity and stability. However, the variations in abundance, occurrence and species composition at the study stations were influenced by the presence of macrophytes, sediment type, extent of pollution, availability of organic matters, seasons as well as rate of predation. The low diversity in some areas is an indication of pollution stress (Edward, and Ugwumba 2011). Some macro-invertebrates especially the arthropods thrive well in the presences of macrophytes for egg laying and attachment.

CONCLUSION

In conclusion, macro-invertebrate fauna of Yewa Lagoon is dominated by the Gastropoda species and more fauna abundance was recorded in the wet season and at Iyafin.

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Checklist Of Phytoplankton Species Of Waters Around The Festac Creek, Lagos Nigeria

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ABSTRACT

The study was conducted to uncover Phytoplankton occurrence and distribution in five sites (Oke-Afa, Ago, Festac creek, Reservoir and Festac Link Bridge) of the Lagos Lagoon from November 2021 to April 2022. Phytoplankton sample was collected with a 55 µm mesh size standard plankton net towed from a motorized boat for 5 min at low speed and transferred into a well labeled plastic container with screw cap. Each sample was preserved with 4% unbuffered formalin and stored in the laboratory , microscopic analysis was done after 48hours. Five main algal groups were recorded namely Bacillariophyta, Cyanophyta, Chlorophyta, Dinoflagellates and Foraminifera. A total of 70 species belonging to 40 genera were observed. Diatoms formed the most abundant group making up 36 species from 22 genera. Cyanobacteria with 16 species from 6 genera, Chlorophyta with 9 species from 6 genera, Dinoflagellates 8 species from 5 genera and the foraminifera with 1 specie. Comparatively, a higher number of species was recorded in the dry season than in the wet season. The findings from this study provides useful information on the checklist of plankton species which could be potentially used as bio-indicators for assessing and monition the creek.

Keywords: Creek, checklist, algae, phytoplankton.

INTRODUCTION

Checklists of phytoplankton species in Nigeria have been documented by different workers even from the last century (Mills, 1932; Fox, 1957; Holden and Green, 1960; Imevbore, 1965; Egborge, 1973; Nwadiaro and Ezefili, 1986). Kadiri (1999) presented a list of phytoplankton species in some coastal waters of Nigeria and Opute (1991) presented a similar list for the phytoplankton of Warri/Forcados estuary. In the last two decades, there has been increasing interest in phytoplankton studies in Nigeria. This may be as a result of increased awareness of their importance in assessing the quality of water bodies, utilization of algal biomass for biofuels and bioremediation. Phytoplankton can be beneficial and/or harmful to ecosystems and public health. Their beneficial use include: acting as biological indicators, where their presence, absence, diversity, abundance and distribution are used to determine the health (nutrient) status or quality of an aquatic environment (Reynold, 2006). Phytoplankton form the base of any aquatic food chain and organic production in the coastal ecosystem (Carol and Timothy, 1993). They are the sources of oxygen in the aquatic systems and are the main primary producers in the food web (Akomeah et al., 2010). It is therefore imperative to study their taxonomy (Atici, 2002). In a pioneering report of phytoplankton species in off shore waters of Nigeria, Nwankwo and Onyema (2004) published a list of 63 species from offshore Lagos. The FESTAC creek is linked to the Porto-Novo creek, it flows into the badagry creek, and into the Atlantic Ocean through the Lagos harbour. Presently, no work has been published on the phytoplankton flora of waters around the Festac creek. The aim of this study is to produce a checklist of the phytoplankton community of the waters around the Festac creek and provide a systematic list that will therefore be useful in measuring our knowledge of the phytoplankton in the region and Nigeria.

MATERIALS AND METHODS

Description of study area:

Five sampling stations were chosen between latitudes 6°50′ and 6°2′ N and longitudes 3°18′ and 3°30′ E) and were characterised by slow flowing water.

Table 1: G.P.S. location and station name of sampled areas in the Festac Creek

STATION NO	STATION NAMES	GPS LOCATION
Station 1	Oke – Afa	Latitude 6°50'829N, Longitude 3°29'409E
Station 2	Ago	Latitude 6°48'554N, Longitude 3°30'124E
Station 3	Festac Creek	Latitude 6°27'154N, Longitude 3°18'438E
Station 4	Benny Reservoir	Latitude 6°47'772N, Longitude 3°29'662E
Station 5	Festac Link Bridge	Latitude 6°27'346N, Longitude 3°18'235E

Collection of Phytoplankton Samples

Phytoplankton sample was collected on each occasion and station with a 55 µm mesh size standard plankton net towed from a motorized boat for 5 min at low speed The net was hauled in and the sample transferred into well labeled plastic container with screw cap. Each sample was preserved with 4% unbuffered formalin and stored in the laboratory. After 48 hours and prior to microscope analysis samples were concentrated to 10ml (Nwankwo 1984)

Laboratory Analysis

In the laboratory, the samples were analyzed using a light microscope at different magnifications (X100 and X400). The drop count method described by Lackey (1938) and employed by Nwankwo (1984) was used.

Identification of Species

Appropriate texts were used to aid identification (Smith, 1950; Hendey, 1958, Wimpenny, 1966; Whitford and Schmacher, 1973 Nwankwo, 1984, 1990, 2004a

RESULTS

Five main algal groups were represented in the sampled areas of Festac Creek. These were Bacillariophyta, Cyanophyta, Chlorophyta, Dinoflagellates and Foraminifera. A total of 70 species belonging to 40 genera were observed. Diatoms formed the most abundant group making up 36 species from 22 genera. Cyanobacteria with 16 species from 6 genera, Chlorophyta with 9 species from 6 genera, Dinoflagellates 8 species from 5 genera while the foraminifera with 1 specie. Comparatively, a higher number of species was recorded in the dry season than in the wet season. Table 1 shows a checklist of phytoplankton species of the Festac area waters and their classification. Species that are first reports for South-western Nigeria with regard to existing checklists (Nwankwo, 1988; Nwankwo et al., 2003a, b; Nwankwo and Onyema, 2004; Wujek et al., 2004) are preceded by an asterick on the list (Table 1).

Table 2: A checklist of phytoplankton species of the waters around Festac creek

DIVISION: BACILLARIOPHYTA
CLASS: BACILLARIOPHYCEAE
ORDER 1: CENTRALES
Coscinodiscus rothii
Coscinodiscus wailesii
Coscinodiscus granii
Coscinodiscus radiatus
Coscinodiscus marginatus
Coscinodiscus concinnus
Coscinodiscus gigas
Coscinodiscus perforatus
Coscinodiscus asteromphalus
Coscinodiscus subtilis
Coscinodiscus excentricus
Coscinodiscus centralis
Odontella sinensisOdontella mobiliensis
Odontella alternansOdontella regia
Odontella aurita

Chaetoceros teres *Chaetoceros wighami* *Chaetoceros constrictus* *Skeletonema costatum* *Cyclotella striata* *Campylodiscus clypeus* *Ditylum brightwelii* *Corethron criophilum* *Rhizosolenia hebetata* *Hemiaulus sp* *Melosira italic* *Leptocylindrus danicus* *Hyalodiscus stelliger* **ORDER II: PENNALES** *Pleurosigma strigosum* *Pleurosigma obscurum* *Surirella* *Gyrosigma* *Nitzschia gracilis* *Pinnularia major* *Fragilaria islandica* **Fragilaria oceanica* *Asterionella* *Tabellaria flocculosa* **Synedra ulna var. biceps* Ehrenberg *Thalassiothrix nitzchoides* **DIVISION: CYANOPHYTA** **CLASS: CYANOPHYCEAE** **ORDER I: CHROOCOCCALES** *Microcystis botry* **Chroococcus turgidus* **ORDER II: HORMOGONALES** *Lyngbya* *Oscillatoria acuta* *Oscillatoria agardhii* *Oscillatoria subbrevis* *Oscillatoria rubescens* *Oscillatoria princeps* **Oscillatoria formosa* *Oscillatoria obscura* *Oscillatoria nigro viridis* *Oscillatoria limosa* *Oscillatoria brevis* *Phormidium bohneri* *Spirulina platensis* *Spirulina subsalsa*

Aphanotheca stagnina *Arthrospira platensis* **DIVISION: DINOPHYTA** **CLASS: DINOPHYCEAE** **ORDER I: PERIDINIALES** *Ceratium macroceros* *Ceratium longipes* *Ceratium furca* **ORDER II: DINOPHYSIALES** *Dinophysis caudate* **ORDER III: NOCTILUCALES** *Noctiluca sp* **ORDER IV: PROROCENTRALES** *Prorocentrum lima* **DIVISION: CHLOROPHYTA** **CLASS: CHLOROPHYCEAE** **ORDER I: CHLOROCOCCALES** *Pediastrum duplex* *Pediastrum simplex* *Pediastrum integrum* *Scenedesmus sp* **ORDER II: ULOTHRICALES** *Ulothrix sp* **ORDER III : ZEGNEMATALES** *Closterium acerosum* *Closterium acutum* ORDER IV : CHLORELLALES *Acanthosphaera zachariasi* **DIVISION: EUGLENOPHYTA** **CLASS: EUGLENOPHYCEAE** **ORDER I: EUGLENALES** **Phacus* **DIVISION: CILIOPHORA** **CLASS: OLIGOTRICHEA** **ORDER : CHOREOTRICHIDA** *Codonellopsis oricnialis* *Tintinnopsis cylindrical* *Tintinnopsis radix* *Favella ehrenbergii* *Favella azorica* **DIVISION: HAPTOPHYTA** **CLASS: PRYMNESIOPHYCEAE** **ORDER : COCCOLITHALES** *Coccolith sp* **DIVISION: FORAMINIFERA** **CLASS: GLOBOTHALAMEA**

ORDER : ROTALIIDA *Globigerina bulloides*

DISCUSSION

In the waters around the Festac Creek, phytoplankton diversity was higher in the dry than the wet season and diatoms were more important group among the phytoplankton categories recorded. Nwankwo (1988) had already reported that phytoplankton production in the Lagos lagoon was high and principally dominated by diatoms. Similar dominance of diatoms among phytoplankton assemblages have been reported by other ecologists in the coastal waters of Nigeria (Imevbore, 2006, Nwankwo 1988, 1998a, b; Nwankwo and Onyema, 2004; Onyema and Nwankwo, 2006). Similarly, Onyema et al. (2003, 2007) reported diatoms dominating the phytoplankton spectrum of the Lagos lagoon. In the Festac creek and surrounding waters, centric diatoms were more in number than the pennate diatoms. The attributed numerous centric forms recorded can be due to the effect of tidal mixing and actions of flood waters inflow that probably scours up the phytobenthic forms into the plankton of the Festac creek and surrounding waters. The flushing of planktonic algal forms towards the sea during the rains by flood waters, could also account for the reduced phytoplankton diversity in the wet season. Similarly, reduced phytoplankton diversity in the wet season may be linked to the low water clarity which reduces the amount of light available to the planktonic algal component for photosynthesis. Onyema and Nwankwo (2006) also reported similar inferences for the Ijora creek phytoplankton regime. In the waters around the Festac creek, there existed environmental gradients from the habour to areas in the creek further inland and the phytoplankton assemblages and distribution reflected these trends. The exact trend of environmental characteristics and trends were not known for the creek till now. About 15 phytoplankton species were reported to be potentially harmful/toxic bloom species Nwankwo et al. (2003b) had already reported on the toxins/potential danger and reported harmful effects of some of these species in South-Western Nigeria and especially for the Lagos lagoon. There is need for other extensive ecological studies to be carried out in the waters around Festac creek.

CONCLUSION

This study provides an important scientific information on the checklist of phytoplankton species which could be potentially used as bio-indicators for assessing and monition the creek.

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Control of the fish beetle (*Dermestes maculatus)* on smoked African mud catfish (*Clarias gariepinus)* using various management options

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ABSTRACT

The most popular, widely cultivated and mostly smoked fish in Nigeria is Clarias gariepinus. The efficacy of powder of Piper guineense, NSPRIDUST, Activated charcoal, Rice Husk Ash and Permethrin Dusts was investigated on smoked African mud catfish, Clarias gariepinus infested with fish beetle Dermestes maculatus. One hundred and twenty gram (120g) lot of disinfected smoked Clarias gariepinus were wrapped in black thin-walled polythene bag and placed into separate plastic jars. The powders were thoroughly mixed with ten newly emerged Dermestes maculatus at dosage rate of 0.1, 0.2 and 0.3% weight/weight, put in each jars and then covered with mesh. Similar method was used for control. Each treatment was replicated thrice in a Complete Randomize Design (CRD). Mortality was assessed after 7dand 14dpost-treatment, and weight loss was recorded after 68 d post-treatment.Mortalities induced by the experimental dusts against D. Maculatus were generally poor, except in permethrin dust where impressive kill was recorded. The highest mortality recorded among non-toxic dusts was 40% in NSPRIDUST with 0.3% concentration after 14d post-treatment. Future works should investigate applying this botanical at a higher dose rate or hermetically sealing the vial to entrap the pungent insecticidal volatiles of the dust.

INTRODUCTION

Fish supplies a good balance of protein, vitamins and minerals. It's harvesting, handling, processing, storage and distribution provides livelihood for millions, as well as providing foreign exchange earning to many countries (Aljufaili and Opara, 2006; Akinwumi *et al.*, 2007; Widjaja *et al.*, 2009). It is the most distributed and cheapest form of animal protein products in Nigeria (FDF, 2005; Mufutau, 2012). The Africa mud catsfish, *Clarias gariepinus* is the most popular, widely cultivated and mostly smoked fish in Nigeria (Aderolu and Akpabio, 2009).

One of the challenges facing the catfish industry is its high susceptibility to attack by insects, especially beetle species of the genera, *Dermestes* and *Necrobia* (Okpako and Agbor, 2015). The loss of dried fish to *Dermestes maculatus* especially under traditional storage conditions in Nigeria has been estimated at 40-50% (Lale and Sastawa, 1996; Lale 2002).

Various control measures have been put in place by stakeholders to check the menace by fish beetles. The use of pesticide against insect pests of stored product has long being used and still in use by farmers and fish mongers, but the pesticide/insecticides application caused illness to humans and other animals as well as nuisance to the environment (Sufi *et al.*, 2017). The use of botanicals, particularly medicinal plants and culinary species namely; *Dennettia tripetala* Baker, *Eugenia aromatic* Hook, *Monodoramyristica*Dunal, *Piper guineense*Schum and Thonn, have been tested and effective (Akinwumi, 2011; Olayinka-Olagunju, 2014). Diatomaceous earth (NSPRIDUST), activated charcoal, rice husk ash are all absorbent inert dusts with proven insecticidal actions on grain beetles (Rojht *et al.*, 2010; Shah and Khan, 2014; Ziaee and Ganji, 2016). There is dearth information on insecticidal impact of the selected dust materials on *D. maculatus*. Therefore, the objective of this study is to evaluate *P. guineense* (botanical), diatomaceous earths (NSPRI DUST), activated charcoal, rice husk ash and permethrin dusts for their effectiveness in checking *D. maculatus* population growth in fish stored in thin-walled polythene bags in the humid conditions of Port Harcourt, River State, Nigeria.

MATERIALS AND METHODS

Collection and maintenance of insect culture

The beetles (*D. maculatus)* were reared inside in the laboratory of the Nigerian Stored Products Research Institute (NSPRI), Port Harcourt, Rivers State, Nigeria at 27.5 ± 2°C and 86.5 ± 5% R.H. The beetles were obtained from the infested smoked dried fish purchased at Mile 3 market, Port Harcourt, River state, Nigeria. Unsexed adult insects were introduced into plastic drums that contained uninfected fish, allowed to mate and lay eggs. The new adults that emerged later were used for the tests. Several generations were reared in these cages for the study.

Preparation of Dusts

The five dusts used were prepared in the following ways;

1. The seed of *Piper guineense* is obtained from mile 3 market, Port Harcourt. The seeds were grind in electric grinder and sieved and kept in airtight Kilner jars for study purpose.
2. Diatomaceous Earth (NSPRI DUST®) is gotten from enhanced powder of Bularafa Diatomaceous Earth ground to dust by means of a laboratory mortar and pestle, sieved using a U.S. Standard #200 sieve (0.075 mm openings) (Seeduro Equipment Company, Chicago, IL))and kept in airtight Kilner jars for study purpose.
3. Activated charcoal was processed from Lagos with fine particles.
4. Rice Husk Ash was obtained by burning the Rice Husk obtained at a rice mill plant at temperature of 6oo^{o}C, then placed into the furnace and ashed completely for 5hours. It was cooled and sieved with laboratory sieve of 90µm aperture.
5. Permethrin0.6% Dust was purchased at commercial outlet.

Preparation of the fish sample

African mud catfish, *Clarias gariepinus* was harvested fresh, degutted and cut into sizes. The cut portions were smoked in fish kiln. In order to reduce polyaromatic hydrocarbon load, the fish was removed from the kiln after 3 hrs and transferred to NSPRI's Multicrop dryer where it was dried for 20 hrs at 55-60 ^{0}C (Pessu *et al.*, 2016).It was disinfected in the laboratory by heat in Searchtech (DHG) electrical oven at 60^{o}C for 2hours.

Bioassays

The varying concentration of *Piper guineense*, NSPRIDUST, Activated charcoal, Rice Husk Ash and Permethrin Dusts of 0.1, 0.2 and 0.3% weight/weight were mixed with ten newly emerged adults of *D. maculatus* each in separate 500ml plastic jars. A 120g lot of disinfected smoked *Clarias gariepinus* was wrapped in black thin-walled polythene bag and added to each plastic jar containing different concentration of the dusts. Each jar was closed using a cap lid, which had a hole that was covered with muslin cloth to allow aeration and prevent insects from escaping. Similar set up was set as a control. Each treatment was replicated thrice and arranged at laboratory table using complete randomize design. The mortality of the insect in each treatment was observed in 7th and 14th day post-treatment, and the weight loss after 68d post-treatment were recorded. The data were analyzed by ANOVA and mean calculated are separated using the Turkey's test when significant ($P < 0.05$).

RESULTS AND DISCUSSION

Table 1: Percentage mortality of *D. maculatus* at 7d and 14d post-treatment at 27.5 ± 2°C and 86.5 ± 5% R.H

Treatments	Conc. (%)	7d Percentage Mortality	14d Percentage Mortality
0.1% NSPRIDUST	0.1	$10.00±0.00^{ab}$	$13.33±3.33^{a}$
	0.2	$26.67±14.53^{ab}$	$33.33±16.67^{abc}$
	0.3	$10.00±5.77^{ab}$	$40.00±5.77^{abc}$
0.1% *Piper guineense*	0.1	$6.67±6.67^{a}$	$33.33±12.02^{abc}$
	0.2	$3.33±3.33^{a}$	$20.00±11.55^{ab}$
	0.3	$3.33±3.33^{a}$	$33.33±3.33^{abc}$
0.1% Act. Charcoal	0.1	$20.00±5.77^{ab}$	$23.33±8.82^{ab}$
	0.2	$6.67±6.67^{a}$	$23.33±23.33^{ab}$
	0.3	$30.00±25.17^{ab}$	$33.33±24.04^{abc}$
0.1% Rice Husk Ash	0.1	$30.00±15.28^{ab}$	$36.67±14.53^{abc}$
	0.2	$30.00±5.77^{ab}$	$36.67±6.67^{abc}$
	0.3	$36.67±23.33^{ab}$	$36.67±23.33^{abc}$
0.1% Permethrin	0.1	$70.00±10.00^{bc}$	$93.33±3.33^{c}$
	0.2	$63.33±17.64^{abc}$	$90.00±10.00^{bc}$
	0.3	$86.67±8.82^{c}$	$100.00±0.00^{c}$
Control		$13.33±13.33^{ab}$	$20.00±20.00^{ab}$
F		4.095	3.819
Df		15	15
P<0.05		0.00	0.01

Means±SE and values are means of triplicate samples followed by the standard error of means. Means in the same column with different superscripts for each dusts are significantly different ($p<0.05$).

Table 1 shows that the mortality recorded by the dusts were relatively very low except the permethrin dust. This result also showed that the mortality increase as amount of dust and length of exposure increase. At 7 day post-treatment, the least mortality were recorded by *P. guineense* (all concentrations had mortality of <10%), the Rice Husk Ash performed better at all concentration with mortality of ≥30%, and permenthrin had mortality more than 60% among the concentrations. At 14 day post-treatment, the mortality of dusts increased and at concentration of 0.3%, the hierarchy of mortality in descending order is Permrthrin, NSPRI dust, Rice Husk Ash, Activate d charcoal and *P. guineense* shows 100, 40, 36.7, 33.3 and 33.3% respectively.

Mortalities induced by the experimental dusts against *D. Maculatus* were relatively very low except in permethrin dust where impressive kill was recorded. Poor insecticidal action by the inert dusts (NSPRIDUST, Activated charcoal and RHA) could be as a result of the prevailing high RH at the period of the assay, since high air RH and especially rain, greatly reduces or completely inactivate inert dusts (Subramanyam and Roesli 2000; Arthur 2001; Stathers *et al*. 2008; Korunic, 2013). Future studies should investigate applying this botanical at a higher dose rate because Jatau *et al.*, (2018) reported mortality of 33,3% after 7 day post-treatment with concentration of 12% of *P. guineense* dust or hermetically sealing the vial to entrap the pungent insecticidal volatiles of dust since this botanical has fumigant properties. The extract of *P. guineense* may seems to be toxic than the powder because, Akinwumi *et al.*, (2007) reported high mortality at concentration of >2.5% with the extract of the *P. gunineense*.The oil on the body of fish could also have played a role against the performance of inert dusts because the latter tend to absorb oil, reducing cuticular wax absorption (Korunic, 2013).

Table 2: Percentage weight loss of the fish after68d post-treatment

Treatments	Conc. (%)	Percentage weight loss
0.1% NSPRIDUST	0.1	$33.33±3.48^{cd}$
	0.2	$24.00±5.51^{abcd}$
	0.3	$19.00±1.53^{abc}$
0.1% Piper guineense	0.1	$21.67±3.84^{abcd}$
	0.2	$25.67±4.67^{abcd}$
	0.3	$23.33±4.41^{abcd}$
0.1% Act. Charcoal	0.1	$23.00±2.00^{abcd}$
	0.2	$30.67±6.44^{bcd}$
	0.3	$26.00±7.94^{abcd}$
0.1% Rice Husk Ash	0.1	$19.67±3.18^{abc}$
	0.2	$22.67±3.84^{abcd}$
	0.3	$21.67±5.24^{abcd}$
0.1% Permethrin	0.1	$7.67±1.33^{a}$
	0.2	$11.33±2.03^{ab}$
	0.3	$8.00±2.08^{a}$
Control		$42.00±1.73^{d}$

Means±SE and values are means of triplicate samples followed by the standard error of means. Means in the same column with different superscripts for each dusts are significantly different ($p<0.05$).

Table 2 shows the mean percentage weight loss of the fish(*Clarias gariepinus*) under the effect of the NSPRIDUST, *Piper guineense*, Activated charcoal, Rice Husk Ash and Permethrin dusts and control treatments against hide beetle (*D. maculatus*). The result of this study shows that fish treated with the dusts have high value of mean percentage weight loss when compared with the untreated fish in the control sample. The application of the dusts statistically had a significant (F = 4.528, P= 0.00) effect on the mean percentage weight loss of the fish. The result also revealed that fishes treated with permethrin gave the lowest mean percentage weight loss (between 8 to 8.33%). and the highest mean percentage weight loss (42%) observed in the negative control. The decrease in percentage weight loss of the fishes with dusts that have high percentage mortality observed in the study is similar to the findings of Tefera *et al.*, (2011) and Silva-Aguayo *et al.*, (2004), who reported that decrease in percentage weight loss associated with the greatest mortality.

CONCLUSION

The study has shown that the mortality recorded by nontoxic dusts (NSPRIDUST, *Piper guineense*, Activated charcoal and Rice Husk Ash) were relative less effective when compared with the toxic dust (permethrin), and this could be either attributed to low concentrations of the dusts or non-hermetical condition of the environment of the fish inside the storage facility. Findings from the study recommend that future works should investigate applying this botanical at a higher dose rate or hermetically sealing the vial to entrap the pungent insecticidal volatiles of the dusts.

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Reproductive biology of the common cuttlefish (*Sepia officinalis* Linnaeus, 1758) off Lagos Coast, Southwest, Nigeria.

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ABSTRACT
Cuttlefish is one of the most valuable marine molluscs by-catch by industrial trawlers. Some aspects of reproductive biology were studied on S. officinalis collected off Lagos Coast, Nigeria. A total of 1,082 specimens were sampled from August 2018 to January 2020. The result of sex ratio showed that out of the total of 1,082 specimens, number of males (799) was substantially higher than females (283), resulting in a sex ratio of 1.00:0.35 (male:female). The calculated monthly χ2 test showed that males were significantly more abundant (P<0.05) than females as well as monthly sex ratio off the Lagos coast. The monthly GSI results indicated that the reproductive season of cuttlefish ranged from May to January, with a maximal GSI of 21.41% in November for females and a maximal GSI of 1.9% in April for males. Furthermore, females have two peaks in the year-round spawning period in May and November while males have homogeneous GSI values throughout the cycle except in the month of April during sampling period. The result of the gonadal development of cuttlefish varied with different eggs colour ranging from light yellow to deep yellow depending on the stage of maturity; four stages occurred in males; stage II—Immature, Stage III- Preparatory, Stage IV- Maturing and Stage V- Mature while females ranged from Stage III- Preparatory, Stage IV- maturing, Stage V- Mature and Stage VI- Spent. It is concluded that S. officinalis of all sizes and maturity stages congregate off Lagos coast, thus, spawning period covering the whole year with maximum peaks in May and November.

Keywords: *Sepia officinalis*, Sex ratio, Reproductive biology, Off Lagos Coast.

INTRODUCTION
Owing to the appearance of fins, it is referred to as a cuttlefish. It undergoes internal fertilization, have a high fecundity and growth rate, but has a short life span of 1–2 years (Beasley *et al.*, 2017). According to Duysak *et al.*, (2014), cuttlefish can exhibit variations in its life cycle, living for approximately 2years before exhibiting mass mortality of adults following a spring spawning

period. Gauvrıty *et al*., (1997) studied on the wild populations of *S. officinalis* and concluded that this species has a very long spawning period; moreover, comprehensive study was also performed on fecundity of *S. officinalis* by Laptikhovsky *et al*., (2003). Conversely, few detailed information are available on the reproductive biology of *S. officinalis* in Nigeria. Hence, basic knowledge on some aspects of reproductive biology of *S. officinalis* off Lagos coast is necessary to provide the biological basis for implementation of possible management measures aimed at sustainable exploitation of the resources.

MATERIALS AND METHODS

The study area is located between 6°20'N–6°34'N and 2°45E'–3°60'E and falls within the barrier lagoon complex (200 km). Three notable stations were selected as sampling points for this research based on representing the entire length of Lagos State off the coast of Lagos, Nigeria (Figure 1).

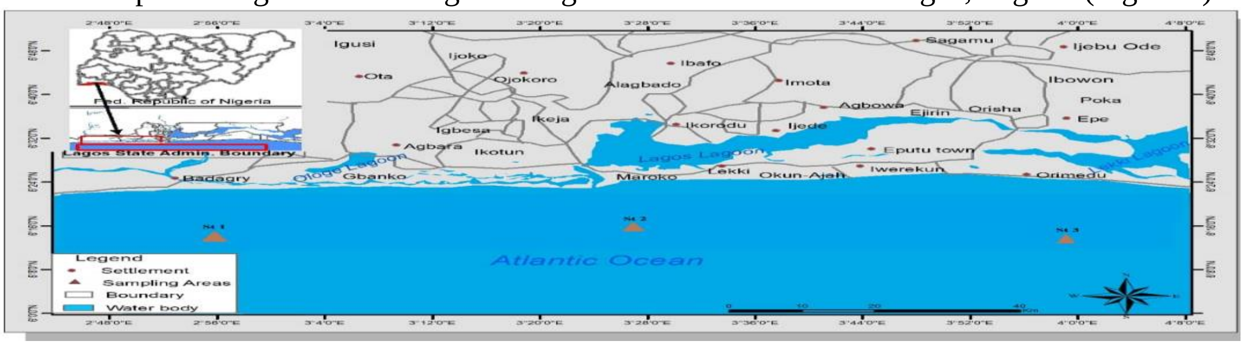

Figure 1: The study area, off the coast of Lagos, Nigeria showing the three sampling stations

A total, of 1,082 (283females, 799males) samples of cuttlefish were collected randomly between 1,000 hrs and 1,200 hrs over a period of 18 mth (August 2018 to January 2020) from 3 stations off the Lagos coast Nigeria. The specimens were immediately identified, sorted and sexed, after which the biometric parameters were measured in fresh condition.

The sex of each cuttlefish was determined using physical examination (presence of the left arm four (IV) hectocotylized (modified arm) typical for males). The male- female ratio statistical hypothesis of H_0 = 1:1 for male and female was tested using the Chi- square as described by (Zibran, 2007) shown in (Equation 1).

$$\chi^2 = \frac{\Sigma\,(\text{Observed} - \text{Expected})^2}{\text{Expected}} \qquad (1)$$

Where χ^2 = Chi-square to be calculated and compared with χ^2 (1 d.f, 5%). Data on reproductive components were done by weighing the following components (to 0.001 g): male testis and female ovary. Paired organs were weighed and recorded. These data were used to determine the maturity indices. Fecundity of this study was taken as the number of ripening eggs in a female prior to the next spawning season (Boyle and Daly, 2000). Maturity stages of male gametes were identified according to description given by (Boyle *et al.*, 1995) and were divided into four different stages based on (Rocha *et al.*, 2001). . The total number of ripe eggs was estimated from the ripe ovaries (stage III) using the gravimetric method and the relationship between female size and egg number is usually described as an allometric functions equivalent to that between size and weight as expressed by Arkhipkin and Mikheev (1992) (Equation 2):

$$Y = a + bX \qquad (2)$$

Where Y = fecundity estimate
X = total length (cm)/ total weight (g)
a = regression constant
b = regression coefficient

The weight of the cuttlefish and that of the gonads were used to determine the Gonado-somatic index (GSI). The GSI of both sexes were calculated for each sampling period using the formula reported by Önsoy and Salman, (2005): (Equation 3).

$$GSI = (\text{Gonad weight/Weight of cuttlefish}) \times 100 \qquad (3)$$

RESULTS

The result of sex ratio showed that number of males (799) was substantially higher than females (283), resulting in a sex ratio of 1.00:0.35 (male:female) shown in (Plate 1). The calculated monthly $\chi 2$ test showed that males were significantly more abundant than females off the Lagos coast. The monthly sex ratio shows that the males *S. officinalis* were more abundant than females in both the dry months (Nov.–Apr.) and wet months (May–Oct.) seasons throughout the sampling period (Figure 2)

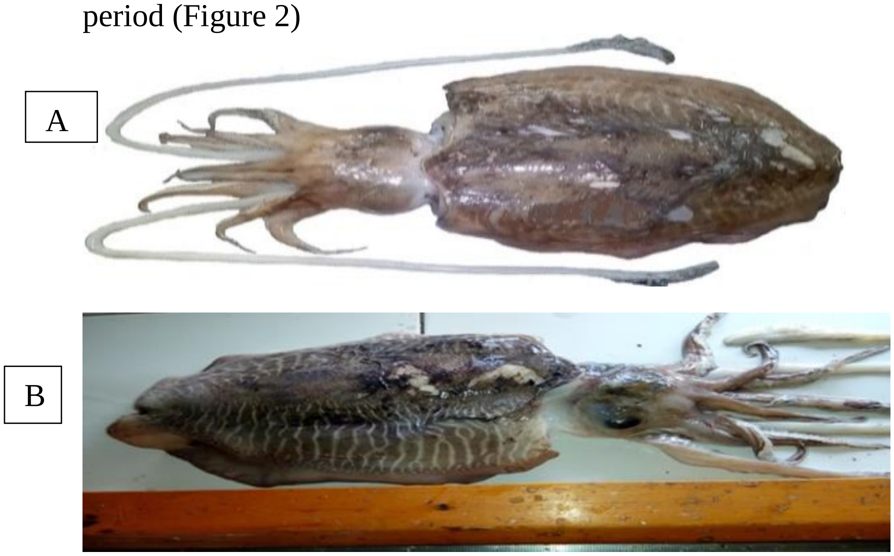

Plate 1: The dorsal view of *S. officinalis* (A) Female and (B) Male

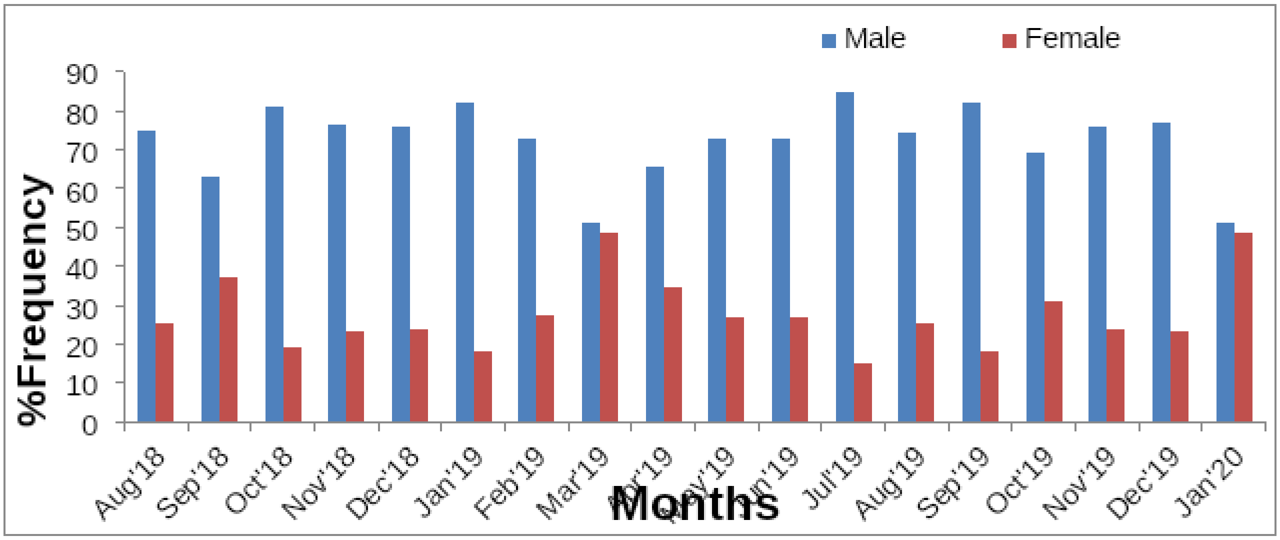

Figure 2: Monthly variation in sex ratio of *Sepia officinalis* off Lagos coast

A total of 50 berried *S. officinalis* were examined for fecundity. It ranged from 7.9 – 21.5cm and 62.0 – 939.5g for length and weight respectively. The fecundity estimates varied from 101 – 291 eggs with an average of 121 eggs. The Log fecundity – Log mantle length and Log fecundity – Log weight relationships are shown in (Figures 3 - 4). The linear regression equations were:

Log Fecundity = 1.3964 + 0.2631LogTW

(n = 50, R^2 = 0.1301, r = 0.3607

Log Fecundity = 0.3186 +1.4865 Log ML

(n = 50, R^2 = 0.3801, r = 0.6165

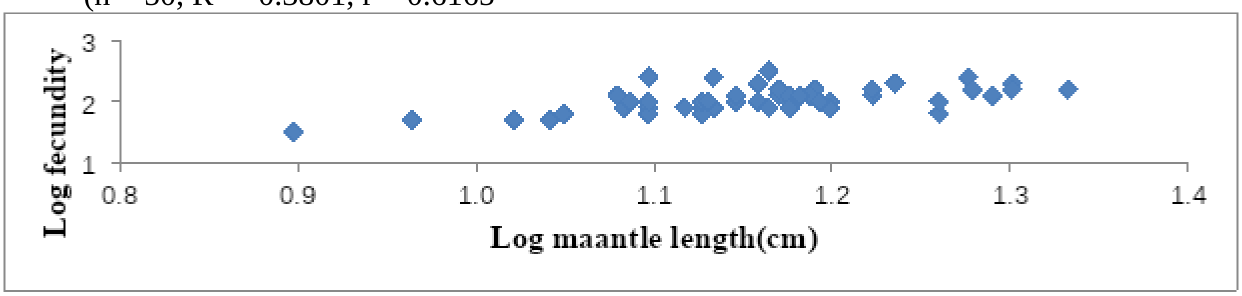

Figure 3: Log mantle length/Log fecundity relationship of *S. officinalis* off Lagos coast.

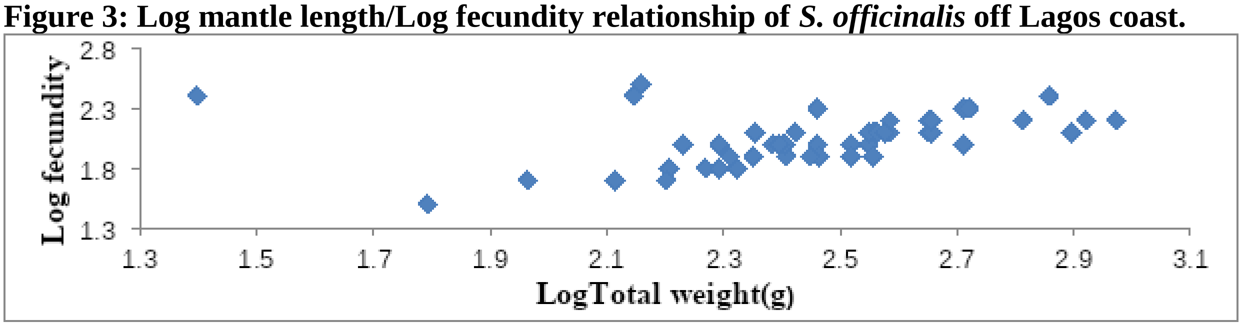

Figure 4: Log Total weight/Log fecundity relationship of *S. officinalis* off Lagos coast.

The result of the gonadal development of cuttlefish varied with different eggs colour ranging from light yellow to deep yellow depending on the stage of maturity. During the period of sampling four stages was observed in male; stage II—Immature, Stage III- Preparatory, Stage IV- Maturing and Stage V- Mature while female ranged from Stage III- Preparatory, Stage IV- maturing, Stage V- Mature and Stage VI- Spent. Hence, preparatory stage (Stage III) were most prominent while the mature (Stage V) were least observed in male while in female Maturing stage (Stage IV) were most prominent and Spent stage (Stage VI) were least occurred across all the studied areas shown in (Figures 5-6)

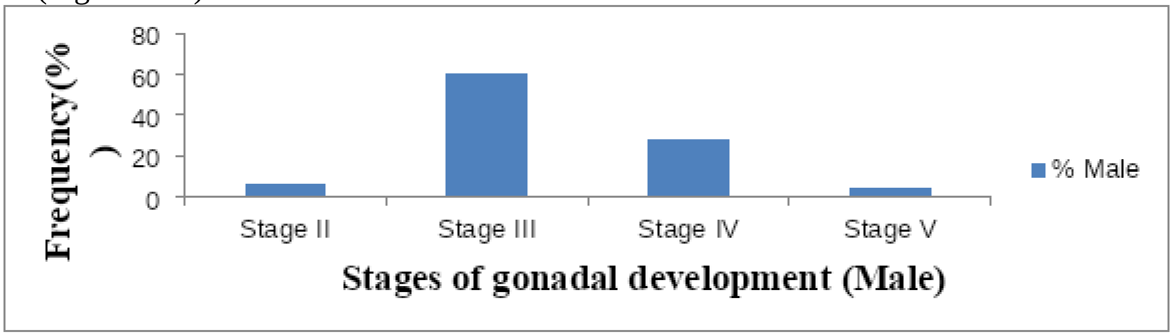

Figure 5: Stages of gonadal development of males S*epia officinalis* collected off Lagos coast (Aug., 2018 – Jan., 2020)

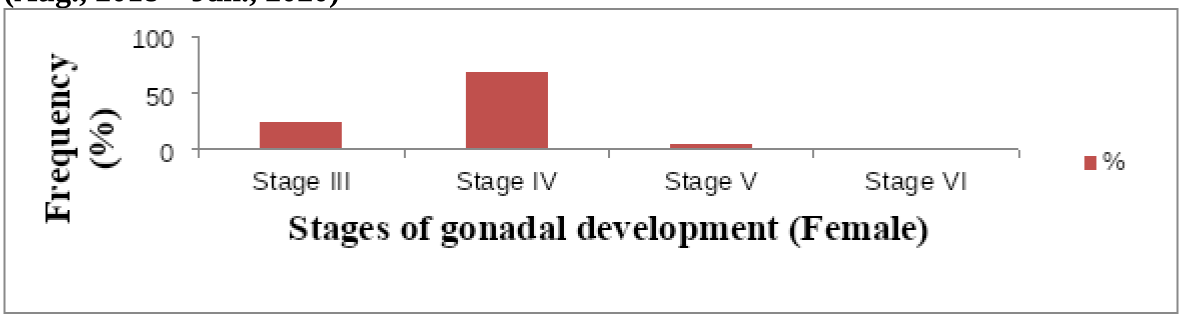

Figure 6: Stages of gonadal development of female *S. officinalis* collected off Lagos coast (Aug., 2018 – Jan., 2020)

The monthly GSI results indicated that the reproductive season of cuttlefish ranged from May to January, with a maximal GSI of 21.41% in November for females and a maximal GSI of 1.9% in April for males. During the sampling period from 2018 to 2020 breeding season, females have two peaks in the year-round spawning period (Figure 7). First peak was observed in May, while the second one was recorded in November. Besides, the males of *S. officinalis* have homogeneous GSI values throughout the cycle except in the month of April.

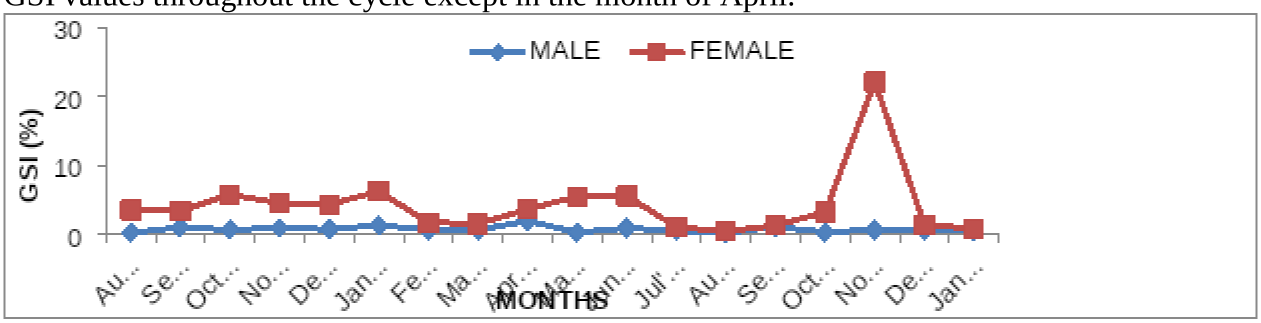

Figure 7: Monthly Gonadosomatic Indices (GSI) of both male and female *Sepia officinalis* specimens.

DISCUSSION

Environmental factors can influence the sex ratio of aquatic organisms either directly or indirectly (Moruf, 2020). The result of sex ratio obtained in the present study differs from those reported in İskenderun Bay, where out of the 2,006 *S. officinalis* examined, 992 (49.45%) were females, and 1,014 (50.55%) were males (Duysak et al., 2014). Similarly, Sujit and Sushant (2018) reported female *S. pharaonis* to be dominant in their study, with a male-to-female sex ratio of 1:1.24. The species' fecundityfor this study estimates varied from 101 – 291 eggs with an average of 121 eggs, was lower than some reported 400 in the west Mediterranean. This could be as a result of geographical differences. Gonado-somatic index(GSI) result of the present work differs from the findings of Önsoy and Salman (2005) who reported two peaks in March and June and spawning period of cuttlefish in Homa lagoon from March to June. Results of the present study are parallel to the findings of Önsoy and Salman (2005). Guven and Ozbaş (2007) observed a spawning period extending throughout the year in *S. officinalis* in the Antalya Bay. Furthermore, these authors noted two spawning peaks (June-July). This shows that the spawning season and the reproductive peaks for the cuttlefish are very variable and probably very closely connected to some abiotic environmental conditions. Türeli-Bilen *et al.,* (2010) reported that spawning period of cuttlefish in Karataş from April to September which is almost similar to the result of the present study off Lagos coast.

CONCLUSION

The study revealed that all sizes and maturity stages of *S. officinalis* congregate off Lagos coast, thus, spawning period covering the whole year with maximum peaks in May and November. Hence, basic knowledge on these aspects of reproductive of *S. officinalis* off Lagos coast is useful to provide the biological basis for implementation of possible management measures for its sustainable exploitation of the resources.

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Comparative Assessment of Heavy Metal Concentration in *Pseudotolithus elongatus* and Tilapia mariae from Commercial Markets, Lagos, Nigeria

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ABSTRACT
This study investigated the level of heavy metals (lead (Pb), chromium (Cr), cadmium (Cd), nickel (Ni), mercury (Hg) and arsenic (As) in *Pseudotolithus elongatus*- brown Croaker, *Tilapiamariae* – Red Tilapia,)from Makoko, Ijora and Mushin markets for three months (November 2021-January, 2022). Lead (Pb) and Cd were not detected in *P. elongatus* across the three markets. Similarly, As was not detected in *P.elongatus* from Ijora and Mushin markets, Hg not recorded in *P. elongatus* collected from Makoko fish market. Values of Cr, Ni, Cu detected in *P.elongatus* across the three markets.While none of the *Tilapia mariae* across the markets contained lead, *T. mariae* from Ijora and Makoko had no arsenic and also Hg and Cd was not detected in *T. mariae* from Ijora and Mushin markets respectively. The Ni content from Makoko (1.8851±1.6270) was significantly higher than those from Ijora and Mushin. Levels of heavy metals detected in *P. elongatus*, across sampled markets were below the standard maximum permissible limits. Therefore, all the fish species examined in this study are considered safe for human consumptions. However, sellers and processors should embrace hygienic practices to avert further contamination of the fish.

Keywords: Safety, markets, fish species, Lagos

INTRODUCTION
Aquatic foods are essential delicacies and form an important staple food for daily living of every human being. One of the prominent aquatic foods in Nigeria is fish. Fish is a fundamental cheapest source of protein and other essential minerals such as omega -3 fatty acids which prevent cardio-related problems (Brawn, 2011). The contribution of fish to animal proteins cannot be overestimated (Abolagba and Melle, 2008).

Heavy metals pollution has become a major concern worldwide due to their toxicity, intrinsic persistence, non-biodegradable nature, and accumulative behaviours. These metals differ from other toxic materials in a way that they are neither created nor destroyed by human. They are inert in the environment and are often considered to be conservative pollutants if left undisturbed. However, the rapid industrialization, urbanization, population growth, agricultural and other human activities have resulted in severe pollution by heavy metals globally, especially in developing countries (Hossain *et al.*,2018).

Basically, heavy metals are unarguably the transition and post transition metals, and the examples which are common are lead (Pb), cadmium (Cd), vanadium (V), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), arsenic (As), nickel (Ni), manganese (Mn), tin (Sn), zinc(Zn), and mercury (Hg) (Lawal Are *et al*., 2018)..

Consequently, an analysis of the levels of heavy metals in fish could be used to investigate anthropogenic impacts on ecosystem and human health. Sequel to the above background, the present study aimed to assess heavy metals concentration in fresh fish from three Markets in Lagos state, Nigeria.

MATERIALS AND METHODS

Study Area

The study area is Lagos State which lies between latitudes 6°25'0"N and 6°32' 30"N and longitudes 3°20' 0"E and 3°25'0"E. However, three sampling stations (Makoko, Ijora and Mushin markets) were selected fromLagos state as shown in figure 1. Mushin fish market is on latitude 6.528660°N and longitudes 3.352564°E, Makoko on latitude 6.494552°N and longitudes 3.386143°E, while Ijora fish market is situated on latitude 6.46639°N and longitudes 3.37666°E. Mushin fish market is found in Mushin Local Government Area in Lagos. It is located 10km north of the city core, adjacent to the main road to Ikeja, and is largely a congested residential area with inadequate sanitation and low-quality housing. Ijora fish market is located in Ijora Olopa, Apapa, Lagos. This market is mainly into Agriculture and farms, food and frozen food where several Dealers are offering ice fish and provide fishery services. On the other hand, Makoko fish market is located on Herbert Macaulay Street Yaba and is one of the longest streets in the State which means it is always busy. Like Mushin and Ijora markets, Makoko fish market opens everyday but the best prices can be gotten very early in the morning on Tuesdays and Wednesdays.

Collection and Identification of Fish Samples

Samples of Fish were collected from the three sampling markets in Lagos State, Nigeria for three months (November 2021-January, 2022). Two samples of fishes(*Pseudotolithus elongatus*- brown Croaker, *Tilapiamariae* – Red Tilapia, were collected from each of the sampled fish markets. The fish samples collected were identified by Fisheries Expert in the Department of Fisheries, Lagos State University.

Pre- treatment of Fish Samples

All samples of fresh fish collected from the markets were transported in polyethylene bags previously treated with 5% $HNO_3$and at the laboratory were cleaned and rinsed with distilled water, following procedure of APHA (1998).The fish samples were later washed with tap water and stored in a freezer at -4°C for 96 hours prior laboratory analysis.

Heavy Metal Analysis in the Fish

All frozen fish samples were defrosted at 25°C which was attained in 4 hours. 6 Samples of whole fresh fish were selected from each sampling market, weighed and oven-dried at 105°C for 28 hours till a constant weight was obtained. Dried samples were grounded with ceramic mortar and pestle, into powdery form and 3g of each sample was digested according to APHA (1998) using Atomic Absorption Spectrophotometer (Buck scientific 210/211 VGP model). The concentration of the metals was calculated in mg/kg. The heavy metals (lead (Pb), chromium (Cr), cadmium (Cd), nickel (Ni), mercury (Hg) and arsenic (As)) concentrations in the sampled fish were determined using Buck Scientific Atomic AbsorptionSpectrophotometer (VGP 210 model, USA).

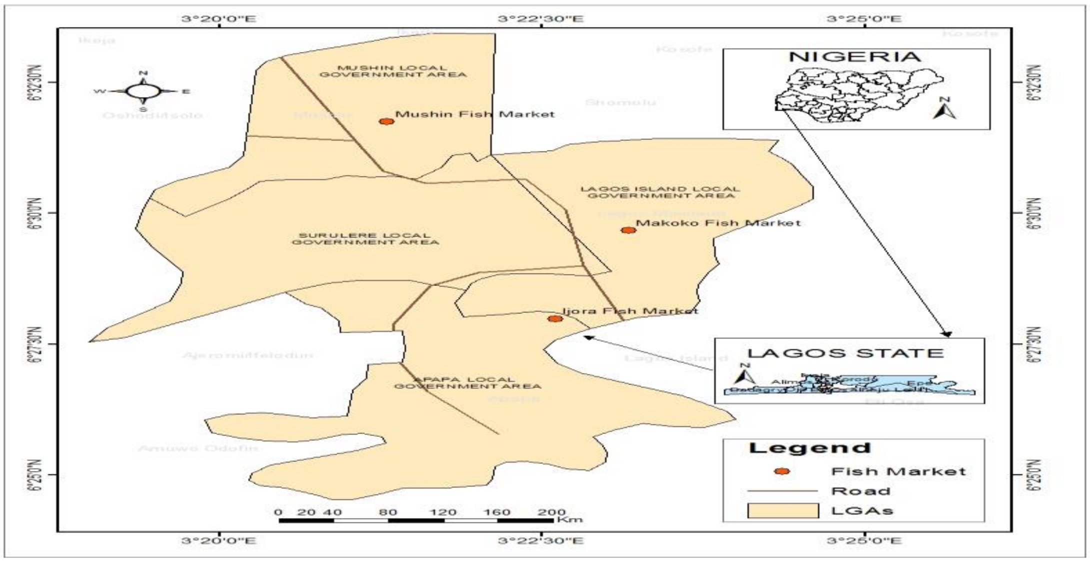

Figure 1: Map showing the location of the selected fish markets (Makoko, Ijora and Mushin) in Lagos State, Nigeria

Statistical Analyses

All Data for variations of the metals in the fish samples were tested by analysis of variance (ANOVA) and results expressed as mean ± standard deviation while LSD Post-hoc test was used to separate the similarity of means. The level of significance was set at $p<0.05$.

RESULTS

Table 1: Concentrations of heavy metals detected in *P.elongatus* from the markets

Heavy Metals	Ijora Market	Makoko Market	Mushin Market
Cr	0.0860 ± 0.0028[a]	0.0825 ± 0.0035[a]	0.0745 ± 0.0021[a]
Ni	0.3040 ± 0.0014[a]	0.3100 ± 0.0014[a]	0.3030 ± 0.0014[a]
As	ND	0.0045 ± 0.0007	ND
Cu	0.0460 ± 0.0028[a]	0.0600 ± 0.0014[a]	0.0765 ± 0.0021[a]
Hg	0.0050 ± 0.0014[a]	ND	0.0125 ± 0.0007[a]
Pb	ND	ND	ND

Cd	ND	ND	ND

Mean with same superscript on the row= not significantly different (p >0.05)
ND = not detected

Table 2: Concentrations of heavy metals detected in *Tilapia mariae* from the markets

Heavy Metals	Ijora Market	Makoko Market	Mushin Market
Cr	0.0955 ± 0 .0007[a]	0.0555 ±0 .0021[a]	0.0630± 0.0014[a]
Ni	0.3080 ± 0.0014[a]	1.8851±1.6270[ab]	0.2915 ± 0.0021[a]
As	ND	ND	0.0080± 0.0014
Cu	0.0725 ± 0.0007[a]	0.1095± 0.0021[a]	0.0470 ± 0.0014[a]
Hg	ND	0.0070 ± 0.0014[a]	0.0040 ± 0.0014[a]
Pb	ND	ND	ND
Cd	0.0085 ± 0.0007[a]	0.0035± 0.0007[a]	ND

Mean with same superscript in the row= not significantly different (p >0.05)
ND = not detected

DISCUSSION

Fish plays a significant role in food and nutrition security across the world, especially in Nigeria, where the people consume fish as a major supplement to carbohydrate-based diets. Fishes are reliable bio-indicators of aquatic ecosystems, since they occupy higher trophic levels and are also an important food source of humans. Since fishes are consumed by human as a major source of protein for many years. Human body is largely susceptible to enriched heavy metal concentration in fishes. Consequently, an analysis of the levels of heavy metals in fish could be used to investigate anthropogenic impacts on ecosystem and human health. In this study, no lead was found in *Pseudotolithus elongates* and *Tilapiamariae*. In this study, no lead was found in *Pseudotolithus elongates*. Arsenic not detected in *P. elongates* and *T.mariae* (from Ijora and Mushin). Also, mercury was not found in *P.elongatus* (Makoko) while cadmium was not detected in *T.mariae* (from mushin). The absence of these toxic metals in most of the fish sampled especially at Makoko and Mushin suggest that the aquatic environments from which these fish species were caught are less susceptible to heavy metals pollution. Different authors such as Babajide and Dauda (2009) and Mekuleyi *et al.* (2021) have shown that anthropogenic activities like agriculture and sewage disposal especially in developing countries where low-end waste management is a common practice, usually result in heavy metals pollution. Furthermore, the absence of Pb, Cd and Hg in most of the fish specimens indicated that the consumers patronizing these markets for fish are not likely to be prone to proteinuria, carcinogenesis, and apoptosis (Jaishankar *et al.* 2014, Engwa*et al.*, 2019). There was no significant difference in the values of Cr and Cu in *P.elongatus* from the three markets. However, Ni content from Makoko was significantly higher than those from Ijora and Mushin. This observation could imply that these fishes are source from similarly ecosystems before they were displayed for sales in these markets. The concentrations of all the heavy metals detected in fishes examined in this study were within the standard permissible limits (FAO/WHO, 2011). Similar findings of fish from Badagry market whose metals content did not exceed maximum permissible limit has been reported by Mekuleyi and Joseph (2017). However, the values of all metals recorded for this study were below those reported in *Chrysichthys filamentosus*, *Kribia nana* and *Pegusa lascaris* (Mekuleyi et al., 2021). Unlike the findings in this study, he reports on some heavy metal concentration in local fish species from different parts of the world (El-Moselhy *et al*., 2014; Thomas and Mohaideen, 2015) including Nigeria (Ugbomeh and Akani, 2016, Mekuleyi *et al*., 2019) were above permissible limits and this indicated a potential risk to humans and other aquatic organisms. Akpanyung *et al.*, (2014) also reported concentrations of some heavy metals (Pb, Cr, Zn and Cd) that exceeded the permissible limit in *Chrysichthys nigrodigitatus* from Ibaka and Ifiayong fishing sites in Akwa Ibom State. However, the values of Pb, Cr, Zn and Cd reported for *E.fimbriata* from Cross River Estuary were below the recommended permissible limits (Udo and Ndunobong, 2016). Similarly, Bolawa and Gbenle (2012) reported that the metal status in *Pseudotolithus senegalensis* and *E.fimbriata* from Carter Bridge River and Makoko River in Lagos, Nigeria, have not exceeded recommended limits for human consumption. Furthermore, research has shown that extent of accumulation of heavy metals in fish is dependent on the metal types, fish species, and the tissues of fish (Mekuleyi *et al.*, 2021).

In line with the outcome of the present study, Kuton *et al*.(2021) reported that the concentrations of the metals -Al, Fe, Mn,Pb ,Cr, Zn,Cd,Ba,Cu and Ni in the tissues of *Malapterurus electricus* collected from fish markets in Lekki were all below regulatory limits and thus were suitable for human consumption. However, Akinsanya *et al.* (2020) reported values of toxic heavy metals in the tissues of *Heterotis niloticus* collected from the same lagoon that are higher than recommended values. Sabreena *et al* (2020) examined the presence of heavy metals (Zn, Cr, Cu, As) in three different fishes (*Labeo rohita,Oreochromis niloticus andHeteropneustes fossilis*)which were collected from a local market in Dhaka, Bangladesh. The data in their paper suggests that the heavy metal concentration found in the fish muscles sampled from local market Dhaka, Bangladesh was significantly high. Therefore, they concluded that there are so many possible health risks to consumers due to the intake of studied fishes under the current consumption rate. As observed for this study, there was variation in the frequency of metals obtained in samples of *P. elongates across* the markets. This observation could be due to the fact that difference fish species have different affinity for metals absorption as a result of its need and environment. Perugini *et al.* (2014) and Anandkumar *et al. (*2017) reported that metal accumulation in varying parts of the body of fish depends on many factors such as water solubility, feeding behaviour, ecology and fish physiology including species, age, size, reproductive state, fish health, bioavailability and different habitats. Also, the accumulation of heavy metals in fish organs could also be driven by physiochemical variables such as pH, temperature, hardness, and exposure duration (Zeitoun *et al.*, 2014).

CONCLUSION

It has been established in this study that the level of heavy metals detected in *P. elongates* and *T.mariae* across sampled the markets were below the standard maximum permissible limits. Therefore, all the fish species examined in this study are considered safe for human consumptions. Also, some toxic metals such as mercury and lead which were not detected at all indicated that certain mercury and lead related diseases in human would be far away from consumers of the sampled fish species. However, sellers and processors should embrace hygienic practices to avert further contamination of the fish.

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The effects of hydro-environmental factors on zooplankton in Agboyi Creek, Lagos

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ABSTRACT
The zooplankton communities in Agboyi creek recorded a high abundance of 1,865 individuals comprising 22 species due to increased nutrient from organic and industrial waste and foliage deterioration from the riparian wetland around the study area. Physico-chemical factors fluctuated during the sampling period due to fluctuation of rainfall, with a record high of 125.80mm in April and 0.00mm in February recording no rain fall, and this significantly affected zooplankton composition and distribution within the creek.

INTRODUCTION
The Agboyi creek is a tidal creek with influxes from the Lagos Lagoon on one side and the from the Ogun river on the other side. It is open throughout the year and receives tidal influences - which are experienced far inland especially during the dry season - from the Lagos lagoon. It is a nursery ground for fish, crabs and herons that also avail the site. (Onyema and Nwankwo, 2006). The creek area is lined by human settlements and is typically a fishing community. The creek also serves as a major drainage channel for the area, receiving domestic waste discharges along with industrial wastes from nearby industries within the Lagos metropolis. Sand mining, mangrove harvesting - for fuelwood and brush parks - are some common practices in the area (Olawusi-Peters and Ayorinde, 2009).

Zooplanktons are an important part of aquatic food chain. They support all aquatic ecosystems by supplying energy from primary producers and recycling nutrients into the water column. They can strongly affect water quality, algal densities, fish production and nutrient as well as contaminant cycling. Their composition and distribution are influenced not only by biological factors such as predators and primary producers, but also by physical and chemical factors and as such can be included in biomonitoring programs because their densities and species composition can be sensitive to changes in environmental conditions. (Adedeji *et al.,* 2013).

This study aims to provide information on the effect of hydro-environmental influence on the zooplankton composition and distribution within the Agboyi creek. The results of this study can be used in water resources conservation and management as species of zooplankton can be introduced to water bodies to enhance fish production.

MATERIALS AND METHODS

Study site: The Agboyi creek is an adjourning creek to the Lagos lagoon, located on its northern side and drains the Ogun River. The sampling station was sampled for six months (November - April).

Collection of water samples: Water samples were collected each month using 75cl plastic containers. They were dipped into the water to collect the water samples and were taken to the laboratory for physical and chemical analysis.

Collection of plankton samples: Plankton samples were collected by standard plankton collection method.

Determination of air temperature (^{0}c): Air temperature was taken in-situ using a mercury-in glass thermometer.

determination of water temperature (^{o}c): The surface water temperature was determined in-situ.

Determination of transparency (cm): This was measured in-situ using a secchi disc.

Determination of total suspended solids (tss) (mg/l): This is estimated by using the Gravimetric Method 22540D.

Determination of total dissolved solids (tds) (mg/l): were determined using Gravimetric Method 2540C.

Collection of rainfall data (mm): data obtained from NIOMR.

Determination of pH: this was determined by the Electrometric Method using the Cole Parmer Test.

Determination of salinity (‰): this was determined using Saline test Salinity Meter (Hanna Instrument HI 98203).

Determination of conductivity (µs/cm): This was determined by using Philips PW9505 conductivity meter.

Determination of alkalinity (mg/l): This was determined using the Titration Method 2320B.

Determination of acidity (mg/l): this was determined using the titration method 2310B (APHA, 1998).

Determination of dissolved oxygen (DO) (mg/L): This was estimated by Titrimetric (Iodometric) Method using the Azide Modification procedure 4500ºC.

Determination of biological oxygen demand (BOD) (mg/L): This was determined using the Winkler method.

Determination of chemical oxygen demand (COD) (mg/L): This was determined by using the Closed Reflux Method 5220C with higher concentration of potassium dichromate solution.

Determination of total hardness (mg/L): This was determined by the buret titration method.

Determination of chloride (mg/L): this was determined in unfiltered water samples by buret titration method.

Determination of calcium (Ca^{2+}) (mg/L): This was estimated using the EDTA Titrimetric Method.

Determination of magnesium (Mg^{2+}) (mg/L): This was estimated using the Titrimetric method.

Determination of nitrate – Nitrogen (NO_3^-) (mg/L): This was determined using the Colorimetric Method 4500D.
Determination of phosphate – Phosphorus (PO_4^-) (mg/L): This was determined using the Colorimetric Method.
Determination of Sulphate (mg/L): This was determined using the Turbidimetric Method 4500 E.
Determination of silica (S_iO_2) (mg/L): The was measured using a pre-calibrated colorimeter (DR2010). **Determination of dissolved inorganic nitrogen (DIN) (mg/L):** This was determined on 10 ml aliquot by cadmium reduction method (HACH Method 8039), with NitraVer-5 reagent powder.
Determination of total dissolved nitrogen (TDN) (mg/L): This was determined using the HACH Method 10072.
Determination of dissolved organic nitrogen (DON) (mg/L): By calculating DON = TDN – DIN (by difference)
Determination of dissolved inorganic phosphate Reactive Phosphorus (Orthophosphate) (mg/L): This was determined by using a HACH DR 3900 spectrophotometer according to Hach Method 8048.
Determination of oil and grease (mg/L): This was determined using EPA Method 418.1.
Determination of copper (mg/L): This was determined using the Atomic Absorption Spectrophotometer (AAS).
Determination of iron (mg/L): This was determined using the AAS.
Determination of zinc (mg/L): This was determined using the AAS.
Determination of lead (mg/L): This was determined using the AAS.
Determination of cadmium (mg/L): This was determined using the AAS.
Determination of manganese (mg/L): This was determined using the AAS.
Determination of chromium (mg/L): This was estimated using the AAS.
Determination of nickel (mg/L): This was determined using the AAS.
Determination of biomass using Chlorophyll *a* (µg/L): determined by using spectrophotometer HACH DR 3900.
Determination of biomass in terms of numbers using counting methods (per ml): This was determined using the Drop Count Method.
Determination of community structure analysis: Species diversity index (d), Menhenicks (D), Species richness (d), Evenness or equitability indices (j) and Simpson's Dominance index (C) were used to estimate the phytoplankton biodiversity. They were calculated using associated equation.
Determination of statistical analysis: Standard deviation, correlation coefficient (r) and coefficient of similarity (S) were determined by equations.

RESULTS AND DISCUSSION

The monthly variations in the physicochemical parameters at Agboyi Creek from November to April are represented in Table 1 below. High air and water temperature values recorded during this study are typical of the region, however, the range of water temperature values are in contrast to earlier observations by Sandison and Hill (1966) reporting that water temperature in the Lagos lagoon never varied more than 4°C. This may be due to increased insolation arising from greater solar radiation, plausibly a reflection of global warming trends. The rainfall values showed great fluctuation, ranging from 0 - 125.80mm. Transparency was relatively low due to the effect of rainfall. The salinity regime was seasonal with high salinities from February to April and low salinities between November and December. The salinity during sampling ranged from 0.1-8.31‰ which confirms that the study site is a brackish ecosystem. pH values are consistent with tidal creeks which are usually slightly alkaline.

Table 1: Monthly variations in water quality parameters at Agboyi Creek, Lagos (November - April)

S/N	PARAMETERS	NOV		DEC		JAN		FEB		MAR		APR		MIN		MAX		MEAN		SD	
		ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2	ST1	ST2
1	**Air temperature (°C)**	33.50	32.00	31.00	32.00	31.10	31.20	29.20	29.80	30.00	33.00	38.00	34.00	29.20	29.80	38.00	34.00	32.13	32.00	3.22	1.45
2	**Water temperature (°C)**	30.50	30.50	30.50	31.00	29.90	29.80	30.00	29.00	32.00	32.00	31.50	31.00	29.90	29.00	32.00	32.00	30.73	30.55	0.84	1.05
	Transparency (cm)	22.00	25.50	17.50	26.00	80.00	69.50	16.50	18.50	51.50	47.50	40.00	40.50	16.50	18.50	80.00	69.50	37.92	37.92	24.85	18.81
4	**Rainfall (mm)**	37.80		2.10		80.60		0.00		110.60		125.80		0.00		125.80		59.48		54.33	
5	**pH @ 25°C**	7.50	7.38	7.29	7.12	7.31	7.24	7.17	7.17	7.74	7.70	7.49	7.47	7.17	7.12	7.74	7.70	7.42	7.35	0.20	0.22
6	**Conductivity (µS/cm)**	257.10	667.00	1671.00	6840.00	9060.00	10210.00	13070.00	13670.00	11600.00	15160.00	7650.00	10470.00	257.10	667.00	13070.00	15160.00	7218.02	9502.83	5220.17	5214.73
7	**Total Suspended Solid (mg/L)**	54.00	30.00	35.00	29.00	20.00	18.00	12.00	15.00	19.00	13.00	23.00	9.00	12.00	9.00	54.00	30.00	27.17	19.00	15.14	8.65

8	**Total Dissolved Solid (mg/L)**	141.10	366.00	913.00	3625.00	5535.70	6238.30	7188.50	8338.70	6380.00	9247.60	4207.50	6386.30	141.10	366.00	7188.50	9247.60	4060.97	5700.32	2919.96	3257.80
9	**Salinity (ppt)**	0.13	0.30	0.91	3.60	4.92	5.51	7.20	7.50	6.33	8.31	4.11	5.60	0.13	0.30	7.20	8.31	3.93	5.14	2.86	2.89
10	**Acidity (mg/L)**	66.20	50.10	20.00	15.00	120.00	110.00	10.00	10.00	9.50	12.30	6.00	10.00	6.00	10.00	120.00	110.00	38.62	34.57	45.74	40.04
11	**Alkalinity (mg/L)**	80.10	88.00	140.00	140.00	201.90	199.90	200.00	202.00	190.00	150.00	165.00	155.00	80.10	88.00	201.90	202.00	162.83	155.82	46.94	42.33
12	**Total Hardness (mg/L)**	24.10	57.00	153.40	645.00	935.40	1047.60	1368.60	1425.70	1197.60	1577.70	775.80	1057.10	24.10	57.00	1368.60	1577.70	742.48	968.35	547.83	553.13
13	**Dissolved Oxygen (mg/L)**	5.12	5.23	5.03	5.34	5.88	6.03	6.14	6.34	6.50	6.56	6.11	6.22	5.03	5.23	6.50	6.56	5.80	5.95	0.59	0.55
14	**Biochemical Oxygen Demand (mg/L)**	6.00	4.00	8.00	5.00	2.00	1.00	2.00	2.00	3.00	2.00	2.00	1.00	2.00	1.00	8.00	5.00	3.83	2.50	2.56	1.64
15	**Chemical Oxygen Demand (mg/L)**	33.00	18.00	30.00	22.00	6.00	3.00	9.00	6.00	9.00	5.00	8.00	2.00	6.00	2.00	33.00	22.00	15.83	9.33	12.22	8.48
16	**Chloride (mg/L)**	71.	165	495	198	270	303	396	412	346	456	226	308	71.	165	396	456	2159.65	282	1574.26	158

		30	.00	.11	1.10	3.20	0.40	1.50	6.50	6.30	6.70	0.50	0.00	30	.00	1.50	6.70		4.95		8.86
17	**Nitrate (mg/L)**	11.82	5.65	24.81	16.83	13.29	12.85	7.09	7.12	4.96	5.87	5.69	3.90	4.96	3.90	24.81	16.83	11.28	8.70	7.43	5.02
18	**Sulphate (mg/L)**	9.00	21.00	65.00	273.60	382.30	430.30	504.00	522.00	440.50	580.00	279.50	380.80	9.00	21.00	504.00	580.00	280.05	367.95	203.01	201.01
19	**Phosphate (mg/L)**	0.43	0.32	0.74	0.40	3.48	3.77	2.21	2.85	1.34	1.19	1.29	1.03	0.43	0.32	3.48	3.77	1.58	1.59	1.11	1.40
20	**Silica (mg/L)**	7.70	8.14	12.10	11.04	1.56	1.58	4.92	4.19	2.79	2.86	4.74	2.77	1.56	1.58	12.10	11.04	5.64	5.10	3.80	3.69
21	**Calcium (mg/L)**	1.40	3.40	9.79	39.20	55.15	61.77	81.36	84.75	71.20	93.80	45.62	62.16	1.40	3.40	81.36	93.80	44.09	57.51	32.40	32.75
22	**Magnesium (mg/L)**	5.10	11.82	31.30	133.00	192.37	215.44	282.96	294.75	247.59	326.17	360.70	218.96	5.10	11.82	360.70	326.17	186.67	200.02	141.71	114.36
23	**Sodium (mg/L)**	40.00	92.01	260.02	1076.10	1494.11	1672.50	2217.60	2310.00	1938.97	2555.51	1261.76	1719.20	40.00	92.01	2217.60	2555.51	1202.08	1570.89	883.29	892.19
24	**Potassium (mg/L)**	1.30	3.10	8.55	34.	50.	56.15	73.44	75.88	62.07	83.12	41.	56.02	1.30	3.10	73.44	83.12	39.44	51.	28.97	29.

					20	18						10							41		25
25	**Zinc (mg/L)**	0.05	0.07	0.05	0.05	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.05	0.05	0.06	0.07	0.06	0.06	0.01	0.01
26	**Iron (mg/L)**	0.18	0.18	0.11	0.11	0.08	0.09	0.10	0.10	0.11	0.09	0.10	0.10	0.08	0.09	0.18	0.18	0.11	0.11	0.03	0.03
27	**Copper (mg/L)**	0.0017	0.0024	0.0023	0.0026	0.0015	0.0018	0.0019	0.0010	0.0012	0.0009	0.0008	0.0007	0.0008	0.0007	0.0023	0.0026	0.0016	0.0016	0.0005	0.0008
28	**Cadmium (mg/L)**	0.0008	0.0009	0.0006	0.0006	0.0009	0.0007	0.0011	0.0006	0.0006	0.0007	0.0008	0.0006	0.0006	0.0006	0.0011	0.0009	0.0008	0.0007	0.0002	0.0001
29	**Lead (mg/L)**	0.0013	0.0009	0.0011	0.0012	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0009	0.0013	0.0012	0.0011	0.0010	0.0001	0.0001
30	**Chromium (mg/L)**	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
31	**Manganese (mg/L)**	0.042	0.028	0.027	0.014	0.053	0.067	0.037	0.031	0.024	0.011	0.016	0.017	0.016	0.011	0.053	0.067	0.033	0.028	0.013	0.021
32	**Nickel (mg/L)**	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
33	**Chlorophyll *a* (µg/L)**	16.	11.	12.	11.	9.	7.80	9.60	9.10	11.	13.	5.	7.00	5.	7.	16.	13.	10.62	9.	3.44	2.

		00	00	10	40	10				20	40	70		70	00	00	40		95		41
34	**Chlorophyll *b* (µg/L)**	0.40	0.90	0.70	0.50	0.30	0.60	0.40	0.50	0.50	0.20	0.30	0.30	0.30	0.20	0.70	0.90	0.43	0.50	0.15	0.24
35	**Phaeophytin *a* (µg/L)**	0.20	0.40	0.30	0.30	0.20	0.20	0.20	0.30	0.10	0.10	0.20	0.20	0.10	0.10	0.30	0.40	0.20	0.25	0.06	0.10
36	**Dissolved Inorganic Nitrate (mg/L, as N)**	2.67	1.28	5.68	3.90	1.16	1.26	0.74	0.95	0.45	0.40	0.43	0.34	0.43	0.34	5.68	3.90	1.85	1.35	2.05	1.31
37	**Dissolved Organic Nitrate (mg/L, as N)**	0.05	0.03	0.08	0.08	3.11	2.91	1.60	1.61	1.12	1.33	1.28	0.88	0.05	0.03	3.11	2.91	1.21	1.14	1.13	1.08
38	**Dissolved Inorganic Phosphate (mg/L, as P)**	0.14	0.11	0.25	0.13	0.11	0.10	0.10	0.10	0.19	0.07	0.09	0.08	0.09	0.07	0.25	0.13	0.15	0.10	0.06	0.02
39	**Oil & Grease (mg/L)**	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.00

Nutrient levels were high due to the high amount of bio-degradable waste discharges in the region and reduced dilution effects from floodwaters. Conductivity values increased with increase in salinity and total dissolved solids, which may be the reason for the increase in total hardness. The trace elements were low throughout the study period except magnesium which had higher values. Studies have shown that the levels of algal pigments in water are influenced by environmental variables and as such, Chlorophyll *a* is an index of total phytoplankton abundance. Chlorophyll *a* values were positively strongly correlated with salinity, conductivity, dissolved oxygen (DO), total dissolved solids (TDS), total hardness and sulphate, and however, negatively correlated with pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), nitrate, silica, iron, copper and zinc.

The total number of zooplankton species identified were 1,865 individuals comprising 22 species which were more in the dry months than the wet months. This high zooplankton diversity is an indication of increased nutrient from organic and industrial waste around the study area. Additionally, foliage deterioration from the riparian wetland flora may also have led to enrichment that eventually emptied into the creek. Such nutrient rich run-offs are more frequent with rain events (Nwankwo 1995). The zooplankton diversity was represented by three divisions namely; Arthropods, Cnidarian and Rotifera. The Arthropoda were represented by nine species from three orders (Order Calanoida, Cyclopoda, Harpacticoda), the Cnidarian were represented by one specie from one order (Semaestomeae), the Rotifera were represented by 1 specie from one order (Ploima) and then the Juvenile stages.

Among the zooplankton divisions, the Arthropods had the largest percentage of (82.57%), followed by the Juvenile stage with (14.75%) and the Rotifera and Cnidaria with (1.34%) in terms of abundance of individuals. The Arthropoda were the majority in abundance in terms of numbers. The genera notable of the Arthropoda were *the Acartia clansii*, *paracalanus parvus, Temora stylifera, Cyclops sp, Oithona nana, Cyclops tranum, Oithona sp, Cyclopina longiatus, microsetella.* The Juvenile stages *Barnacle nauplii*, Barnacle larvae, *Copepod nauplii*, Gastropod larvae, Fish larvae, Copepod egg, Zoea larvae, Cyprus larvae. The Cnidaria representing Jelly fish, while the Rotifera represented by *Lecane bulla.*

Table 2: Community structure indices at Agboyi creek, Lagos (November - April)

	NOV		DEC		JAN		FEB		MAR		APR			
PARAMETERS	**ST. 1**	**ST. 2**	**ST .1**	**ST. 2**	**ST. 1**	**ST. 2**	**ST. 1**	**ST. 2**	**ST. 1**	**ST. 2**	**ST. 1**	**ST. 2**	**Min**	**Max**
Total species diversity (S)	4	2	8	4	6	6	6	8	7	5	5	5	2	8
Total abundance (N)	50	15	165	55	225	130	460	175	220	190	140	40	15	460
Log of Species diversity (Log S)	0.60	0.30	0.90	0.60	0.78	0.78	0.78	0.90	0.85	0.70	0.70	0.70	0.30	0.90
Log of abundance (Log N)	1.70	1.18	2.22	1.74	2.35	2.11	2.66	2.24	2.34	2.28	2.15	1.60	1.18	2.66
Shannon-Wiener Index (Hs)	0.53	0.28	0.86	0.56	0.72	0.53	0.18	0.55	0.64	0.43	0.34	0.65	0.18	0.86
Menhinick Index (D)	0.57	0.52	0.62	0.54	0.40	0.53	0.28	0.60	0.47	0.36	0.42	0.79	0.28	0.79
Margalef Index (d)	0.77	0.37	1.37	0.75	0.92	1.03	0.82	1.36	1.11	0.76	0.81	1.08	0.37	1.37
Equitability Index (j)	0.88	0.92	0.95	0.93	0.92	0.68	0.24	0.61	0.75	0.61	0.49	0.93	0.24	0.95

Simpson's Dominance Index (C)	0.34	0.56	0.15	0.29	0.20	0.42	0.84	0.45	0.29	0.44	0.63	0.25	0.15	0.84

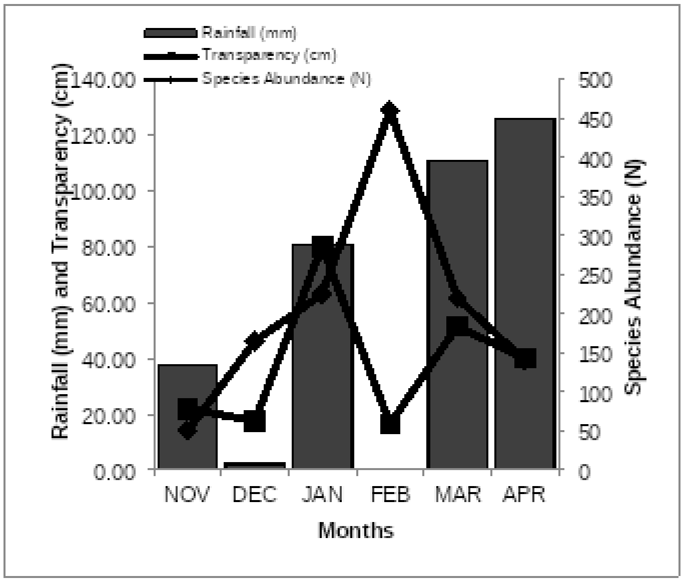

Fig 1: Monthly Variations in species Abundance, Rainfall and Transparency at Agboyi Creek Station 1 (November– April).

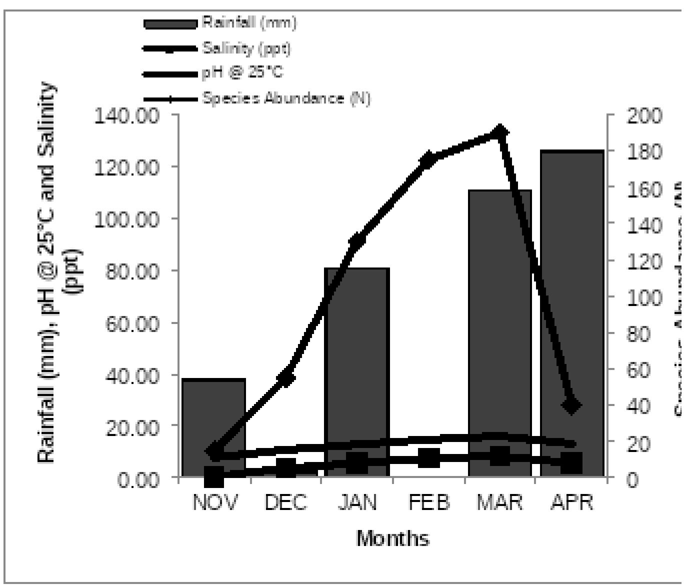

Fig 2: Monthly variation in Species Abundance, pH, Salinity and Rainfall at Agboyi creek Station 2 (November– April)

CONCLUSION

The study of zooplankton, which is - its key position in the trophic chain, gives a fundamental role in aquatic environments, and as a consequence, its study is essential to better understand the functioning of these aquatic systems. So, to have loss of zooplanktons would result in detrimental consequences that can go as far as the loss of biodiversity, thus leading to impairment of the biological equilibrium of creeks and even destruction of the aquatic ecosystems.

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Analysis Of Some Climatological Variables Of Lagos State And Their Potential Impacts On Fisheries

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ABSTRACT

Lagos state is a coastal and the most populous state in Nigeria. It is the economic hub and one of the country's highest fish-producing states. Owing to the geographical setting of the state i.e., its proximity to the Atlantic Ocean, it experiences a unique weather system (coastal climate) that is characterized by both atmospheric and oceanic processes. This unique weather system is affected by sharp changes in heat, moisture, and momentum transfer between the atmosphere and the sea surface, which have direct impacts on marine biodiversity. The extent of these sharp changes can be measured through climatological variables. The present study examined some climatological variables acquired from the NIOMR synoptic weather station, Badore, Lagos, for the year 2021 and their potential impacts on fisheries. The result shows that high temperature was recorded in the dry season and low temperature in the rainy season. Furthermore, the total amount of rainfall recorded through the year was 1411.11mm/hour with a monthly and daily maximum of 8.3017mm/month, 60.41mm/hour recorded in May and 16th of July respectively. High wind speed was recorded in the rainy season while the low wind speed recorded in the dry season with wind directions predominantly varies through the year with average directions in the southwest direction.

INTRODUCTION

The coastal areas often experience unique weather which results in a very special climate owing to their natural settings i.e., the boundary layers (interphase between the land and water), and the interactions with the atmosphere (air-sea interaction). This unique weather phenomenon in the coastal areas is climatologically induced and significantly affected by sharp changes in heat, moisture, and momentum transfer between the atmosphere and the sea surface. Evidently, variabilities in the climatic condition in the coastal environment do not only affect the coastal inhabitants but could also impact fisheries in multiple ways. Climate variabilities can also bring about significant ecological and biological changes to marine and freshwater ecosystems and the resultant fish population (Wabnitz et al., 2018). Climate change is predicted to have major impacts on fish production (Brander 2007). Furthermore, climatic factors influence the spatial and temporal distribution of marine species. Climate variables, specifically the temperature and rainfall, and wind pattern affect the distribution and health of coastal ecosystems, and the productivity of the industries that depend on them, such as fisheries. Lagos state is a low-lying coastal and the smallest state in Nigeria with approximately $3,577\ \text{km}^2$, and a coastline of about 186km. Nigeria's economic hub is the most populated state with 22% of its area covered by wetland (mainly Lagoon and Creeks) with (Odunuga et al., 2012; BRNCC2012). The climate system of the state is typical of a tropical monsoon. The state which is one of the highest fish-producing states in Nigeria will no doubt be impacted by climate variabilities. Hence, a need to monitor the year-to-year climate variables of the state. The present study examined some climatological variables acquired from the NIOMR synoptic weather station, Badore, Lagos, and their potential impacts on fisheries and the coastal environment. This is crucial in understanding the year-to-year climate variability of Lagos state and its potential impact on marine operations such as fisheries.

Figure 1.1. Map of Lagos state showing the location of NIOMR synoptic weather station

MATERIAL AND METHOD

The climatological variables used for the study were obtained from NIOMR meteorological station (Badore station) on an hourly basis from the 16th of January to the 31st of December 2021. The default format of the dataset as logged into the equipment is ACDSee Thumbnail Database Format (DTF) file extension (.dtf) and subsequently converted to excel data (.xlsx) with HOBO software. Quality data control (such as DateTime separation, variables nomenclature, etc.) was performed to prepare the data for Scipy software (python library for scientific analysis) analysis. The quality-controlled climatological variables were then introduced into Scipy software for data analysis. The hourly mean climatological were sliced and resampled into daily and monthly mean data, and each of the climatological variables (Temperature, Wind speed, Wind direction, and Rainfall) was then extracted afterward. No rain-hour (hours without rainfall, i.e., when rainfall amount equals zero) were eliminated from the extracted rainfall data. The hourly and resampled climatological variables (daily and monthly) were plotted with Matplotlib against time. The direction of the winds through the period of the study was also plotted and represented by the wind rose. The variables' hourly, daily, monthly minimum, and maximum value with their respective dates during the period under study were also calculated. Results of the analysis are presented in the result section of the paper

RESULTS AND DISCUSSION

Temperature plays an important role in the lives of fishes (e.g., spawning) and its ecological resources, like food and habitat which can influence individual fitness (Magnuson et al., 1 979). For instance, when temperature departs from optimal for an organism, it will act as a stressor and impair physiology and behavior (Donaldson et al., 2008). Furthermore, the production and catchability of fish in many aquatic ecosystems vary considerably as a result of seasons in their environment (Brander 2007), which is also a function of temperature. The result of the analysis of temperature as depicted in (Figure 3.1) shows that the high temperature was recorded throughout the dry season with a maximum temperature of $30.6776o_C$ recorded in February i.e., toward the end of the dry season. Consequently, the low temperature was recorded during the rainy season with a minimum value of $26.822o_C$ recorded in August. The high temperature recorded in the dry season could impact the temperature of the surface water, and as a result, marine ecosystems could be altered and consequently affect species migration, and breeding patterns, threaten sensitive ocean life such as corals, and change the frequency and intensity of harmful algal blooms, etc. This implies that the high temperature in the dry season does not favor biological abundance, especially in the inland and continental waters, thereby affecting the resilience of capture fisheries in Lagos (Olufemi et al., 2010).

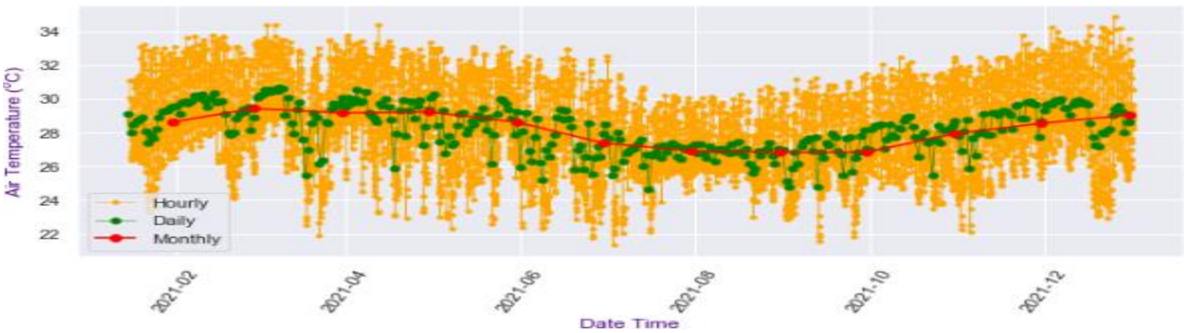

Figure 3.1 Air Temperature along Lagos coastal environment for the year 2021

The rainfall in the marine environment is capable of altering the ocean chemistry and its extreme cases could cause innumerable damage to coastal areas and their marine ecosystems. The total amount of rainfall recorded throughout the year was 1411.11mm/hour. The intensity and duration of rain at a place could impact both the coastal environment and the biological abundance of water in the area. For instance, the daily highest rainfall of 60.41 (mm/hour) was recorded on 16^{th} of July as depicted in (figure 3.2), and this coincides with the day most parts of Lagos were submerged. Such events favor biological abundance as heavy rain causing flooding of terrestrial vegetation has been identified as the ultimate cue for the spawning of cyprinids (Hontela et al., 1990).

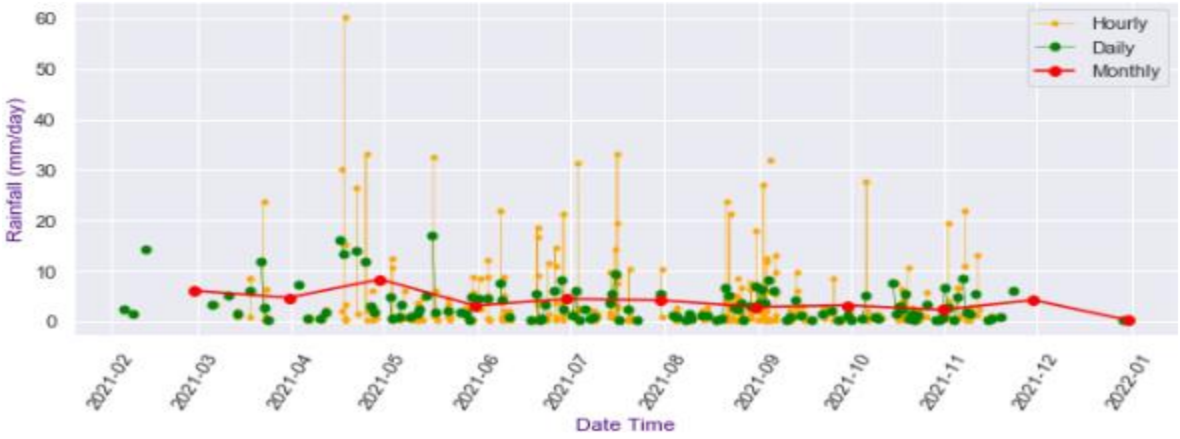

Figure 3.2. Rainfall along Lagos coastal environment for the year 2021

Effluents from the terrestrial vegetation consist of various nutrients which are washed into the water through runoff, thus making the water nutrient-rich (Ayinde et al., 2021). This has made the rainy season favorable to biological abundance thereby increasing the number of capture fisheries in Lagos (Olufemi et al., 2010). Although severe floods may reduce fish density and biomass and influence community composition (Milner et al., 2012). The wind system has also been identified as one of the most important climatological variables in the ocean as it drives the coastal upwelling systems, consequently driving primary productivity and fishery production. Upwelling areas on the continental shelf contribute 20% of global fish production while occupying less than 1% of the world's oceans' surface area (Mann, 2000). Biological production in upwelling areas induced by wind varies from year to year and between locations according to the magnitude and direction of the strongest wind, thereby causing associated fisheries to vary. Analysis of wind as shown in (Figure 3.3) shows that the highest values were recorded in the rainy season specifically in August, and the low values were recorded during the dry season with the lowest recorded in December. The wind results further show why the rainy season could be more biologically productive than the dry season.

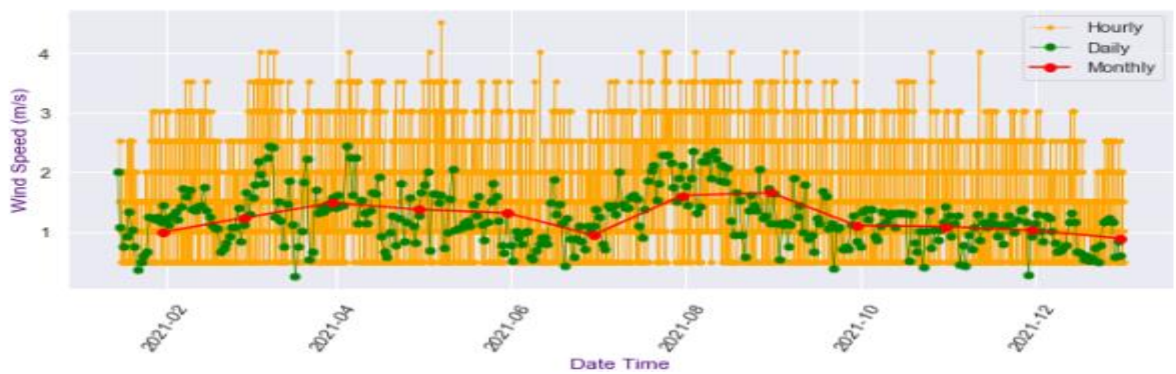

Figure 3.3. Wind Speed along Lagos coastal environment for the year 2021

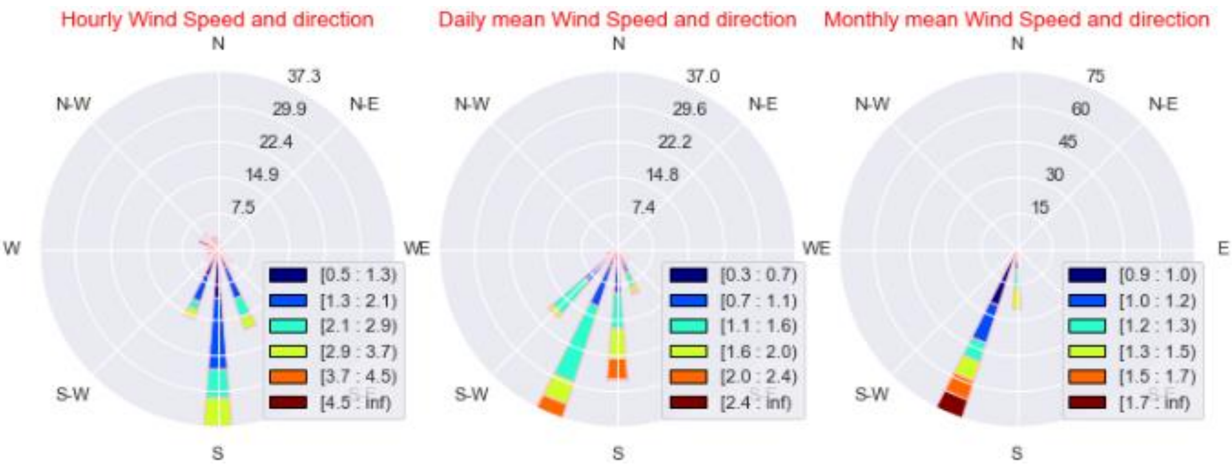

Figure 3.4. The direction of wind along Lagos coastal environment for the year 2021.

The wind direction analysis represented with wind rose as in (Figure 3.4) shows that wind direction predominantly varies through the year with average directions in the southwest direction. This result further confirms the prevailing high-pressure southwest monsoon wind from the Atlantic that pushes the inter-tropical front to the Sahara (northern) region of Nigeria, which practically defines the Nigerian's climate system. Figure (3.5) shows the spatial seasonal fish distribution and the depth as they were caught by a fishing trawler. It was discovered that the highest number of fish were caught during the rainy season.

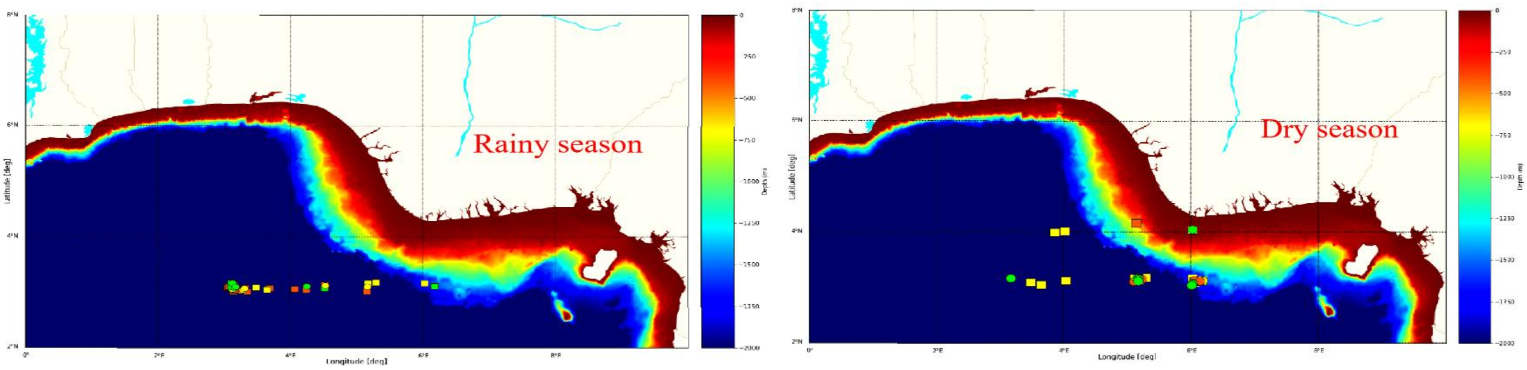

Figure 3.5. Spatial seasonal fish distribution as recorded by fishing trawler 2021.

CONCLUSIONS

Some climatological variables of Lagos state and their potential impacts on fisheries have been analyzed using a well-structured scientific analytical method. Results of the analysis show unique trends in the climatological variables through the year 2021 and their possible implications for the marine weather system. This is paramount in understanding the climate of Lagos state and its potential consequences on fisheries.

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Ecological Quality Status of the Eastern flank of Nigeria Offshore using Macrobenthic Invertebrate as Bio-Indicator of Pollution

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ABSTRACT
The intensity of anthropogenic and natural impacts as stressors has increased significantly overtime due growing demand for natural resources from the marine environment. This study assessed the ecological quality status (EcoQs) of Eastern Nigeria flank offshore using macrobenthic assemblages as ecological biotic indices (AZTI's Marine Biotic Index, multivariate-AMBI, Biotic Index and BENTIX). Sediments were collected across eight (8) stations from the Eastern flank using Van-Veen grab and water with a Niskin water sampler, measured onboard the RV-BAYAGBONA research vessel using a multi-parameter checker, HORIBA-U53.The analysis of variance (ANOVA) showed significant variations ($p<0.05$) in the physico-chemical parameters of Eastern Nigeria Offshore. A total of twenty-four (24) benthic macrofauna across the eight stations belonging to three (3) Phyla – Mollusca (95.08 %), Arthropoda (3.59%), and Annelida (1.23 %) were recorded. The abundance (244) and density (101.7 m^2) of macrobenthic assemblages was observed at the Eastern flank. The ecological quality index AMBI, of the Eastern Nigeria offshore had 51.25% slightly disturbed marine environment (AMBI - 1.5, 1.4, 1.3; M-AMBI – 0.5, 0.6 and 0.6; BI – 2 across station 3, 4, and 5) which indicates moderate to good ecological status. The Shannon-Wiener index of diversity ranged from 1.53 to 3.62 at the Eastern flank. The outcome of these findingscan support future management practices and policies in Nigeria offshoreusing benthic fauna as a robust bioindicator of pollution.

Keywords: Macrobenthic Assemblage, Ecological Quality Status, Eastern Nigeria, Offshore

INTRODUCTION
Macrobenthic fauna are considered to be useful biological indicators to assess the pollution impacts of the any aquatic environment. The intensity of anthropogenic and natural impacts as stressors has increased significantly overtime due growing demand for natural resources from the marine environment (Halpern *et al*., 2007). Stressors are commonly associated with varying categories of contaminants, loss of habitats, overexploitation of species, intrusion of invasive organisms and climate change (Jackson *et al*., 2001; Kappel, 2005). Marine ecological quality status can be estimated through a series of univariate measures of different nature, such as

indicator species, diversity measures and contaminant levels (Borja*et al.*, 2000; Labrune *et al.*, 2012). Usually, there are some variables such as salinity, sediment texture and food availability which plays most essential role in determining the faunistic composition of benthic communities. However, the relative significance of the various factors can differ considerablyamong habitats and regions. Thus, the objectives of this study are to determine the macrobenthic distribution patterns in the Eastern Nigeria Offshore, delineate the ecological quality status of the Nigeria offshore using macrobenthic assemblages, and establish the fundamental environmental variables that influence the distribution and composition of macrobenthic assemblages in the eastern Nigeria offshore.

MATERIALS AND METHODS

Study Area and Sample collection

The study area is the South-Eastern flank of Nigeria offshore which lies between latitudes $04^0$00'N and $04^0$40'N and longitudes of 07^0 20'E and 08^0 20'Ealong the Gulf of Guinea and mostly characterized by a tropical climate with a high temperature and humidity. Some anthropogenic activities such as oil and gas platforms for exploration and exploitation mostly predominates the South-Eastern/Southern flank offshore Nigeria.

Measurement of Environmental parameters of water

Water samples were collected using a Niskin bottle at each sampling station. The physico-chemical parameters measured and analyzed were water temperature, dissolved oxygen (DO), pH, alkalinity, and salinity onboard using a multi-parameter checker - HORIBA-U53. Fixed water samples were transported to the Department of Biological Oceanography laboratory at the Nigerian Institute for Oceanography and Marine Research, Lagos, for nutrients (nitrate, phosphate, and sulphate) were determined using spectrophotometric method at optical densities of 880nm, 543nm, 420nm and 430nm respectively (APHA, 2005).

Benthic macroinvertebrate Analysis

Composite sediment samples were collected across eight (8) stations at the Eastern flank of the Nigerian offshore waters using a 0.1 m^2 Van-Veen grab onboard the RV-BAYAGBONA research vessel in August 2022. Contents of the grab were washed with seawater through a sieve of 0.5mm mesh size. Benthic macro invertebrates were collected from the sieve and preserved with 10 % formalin in labeled jars for further analysis. Subsequently, the preserved benthos samples were adequately sorted and identified following standard protocols (Barnes, 1994; FAO, 1998; Branch *et al.*, 1998).

Figure 1: Sampling stations within the Eastern flank of the Nigerian offshore waters

Ecological Indices

The ecological indices utilised for the comparative study are the AZTI's Marine Biotic Index, multivariate-AMBI,Biotic and BENTIX indices to ascertain the ecological quality status of the Eastern flank of the Nigeria offshore waters in response to environmental stressors. Macrobenthic assemblages are grouped into five (5) ecological groups (EG I, EG II, EG III, EG IV, and EG V) centered on the levels of sensitivity to anthropogenic stressors (Sany *et al.* 2015) and the classification scales of indices are presented in Table 1. The BENTIX indices involve a sensitive group (%GS is the relative abundance of %GI, and %GII) and tolerant species (%GT is the relative abundance of %GIII, %GIV, and %GV) (Cardoso *et al.* 2012). The BENTIX equation is as follows; $\mathbf{BentixIndex} = (\mathbf{6} \times \%\mathbf{GS}) + (\mathbf{2} \times \%\mathbf{GT})/\mathbf{100}$

Table 1: Ecological indices with scales classifications

AMBI[a]	M-AMBI	Biotic index	BENTIX	EcoQs	Ecological group	Disturbance classification
0.0 < AMBI ≤ 1.2	≥ 0.77	0-1	4.5 – 6.0	High	I and II	Undisturbed
1.2 < AMBI ≤ 3.3	0.53 -0.77	1.1-3	3.5 – 4.5	Good	III	Slightly disturbed
3.3 < AMBI ≤ 4.3	0.39 – 0.53	3.1-4	2.5 – 3.5	Moderate	IV – V	Moderately disturbed
4.3 < AMBI ≤ 5.5	0.2 – 0.39	4.1-6	2.0 – 2.5	Poor	V	Heavily disturbed
5.5 < AMBI ≤ 7.0	<0.2	≥7	0 – 2.0	Bad	Azoic	Extremely disturbed

BI- Biotic index, Ecological quality status (EcoQs)

Statistical Analysis

Macrobenthic fauna composition and Physico-chemical parameters were subjected to multivariate analysis (canonical correspondence analysis- CCA, and hierarchical clustering Bray-Curtis similarity indices) utilizing the SPSS v.25 and PAST 4.11 (Hammer *et al.*, 2001) software package and Ecological Biotic Indices to ascertain the ecological quality status (Cardoso *et al.* 2012). The Physico-chemical parameters of the water were analyzed using analysis of variance (ANOVA) at 0.05 level of significance, while ArcGIS 10.6 software was used to generate map of the sampling stations.

RESULTS AND DISCUSSION

The mean variation of physico-chemical parameters of the Eastern Nigeria offshore are presented in Table 2. The analysis of variance (ANOVA) showed significant variations ($p<0.05$) in the physico-chemical parameters of Eastern Nigeria Offshore. Further analysis using Duncan Multiple range test (DMRT) revealed significant differences ($p<0.05$) in sulphate and total dissolved solids (TDS) at the Eastern Nigeria Offshore.

Table 2: Mean variations of physico-chemical parameters of the Eastern flank Nigeria offshore

Parameters	Eastern offshore		
	Mean ± S.E	**Min**	**Max**
Water Temperature	27.41 ± 0.43^{a}	25.89	29.41
pH	7.80 ± 0.06^{a}	7.50	7.92
Conductivity	46.90 ± 0.25^{a}	46.00	47.80
DO	7.59 ± 0.21^{a}	6.80	8.53
TDS	28612.50 ± 135.54^{c}	28100.00	29100.00
Salinity	30.49 ± 0.17^{a}	29.85	31.08
Nitrate	0.01 ± 0.0^{a}	0.00	0.03
Phosphate	0.07 ± 0.02^{a}	0.00	0.19
Sulphate	1265.00 ± 186.69^{b}	0.00	1580.00
Turbidity	0.18 ± 0.13^{a}	0.00	1.00

Distribution and Composition of macrobenthic assemblages

A total of twenty-four (24) benthic macroinvertebrate fauna across the eight stations from eastern Nigeria offshorebelongingto three (3) Phyla – Mollusca (95.08 %), which wererepresented by 20 species, Arthropoda (3.59%) which was represented by 2 species and Annelida (1.23 %) with 2 species (Figure 2). Bivalvia (61.07 %) were predominant while Polychaeta and Malacostraca were the least abundant class.

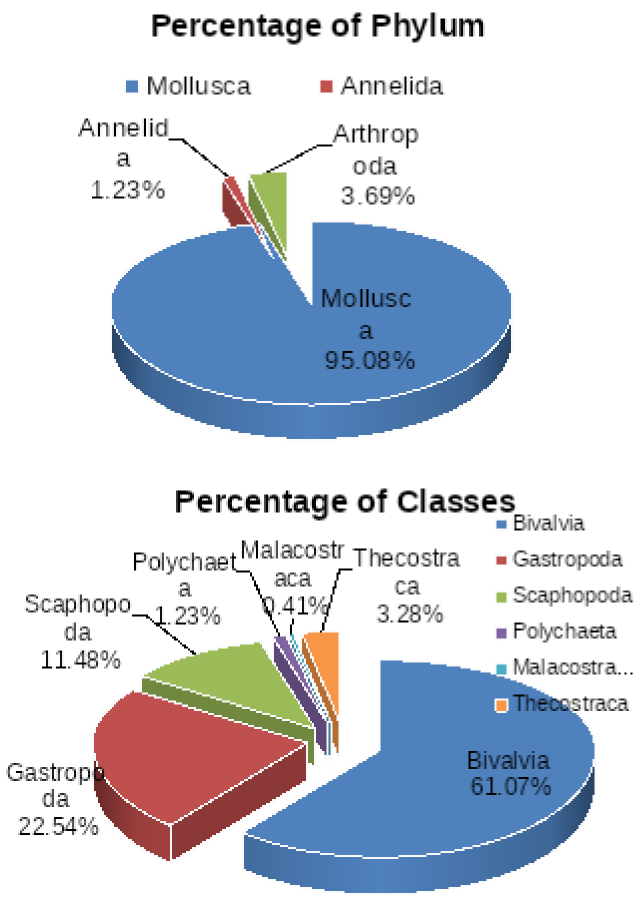


Figure 2: Percentage of the phyla and class constituting the macroinvertebrate fauna from Eastern Nigeria offshore

Abundance and Density of Benthic macrofauna assemblage

The abundance and density of macrobenthic assemblages recorded higher numerical abundance of 244 species and 101.7 m^2 from Eastern offshore.

Ecological indices of benthic macrofauna

Macrobenthic invertebrates are crucial parts of the marine environment as they support significant ecological functions such as bioturbation and nutrient recycling, and contribute substantially to energy flow from primary organic sources to upper trophic levels (Bolam and Eggleton 2014; Saulnier*et al.*, 2019).The ecological quality status of the Eastern Nigeria offshore across eight (8) stations is shown in Table 3. Slightly disturbed levels of AMBI (1.5, 1.4 and 1.3), M-AMBI (0.5, 0.6 and 0.7), and BI (2) were observed across stations 3, 4 and 5 and BENTIX (5.8) at Station 5 respectively. The AMBI Ecological quality status (Figures 3), macrobenthic species-ecological group distribution and M-AMBI quality status (6), while the benthic community was dominated by ecological groups I and II (0 – 100 %: sensitive species) and ecological group III (0–5.6 %: tolerant species). Based on water quality directive of Shannon-Wiener Index, the relationship between the indices and ecological level explained as follows: high status: >4, good status: 3-4, moderate status: 2-3, poor status: 1-2, and bad status: 0-1 (Kalyoncu and Zebek, 2011). In this study, the values of theShannon-Wiener index of diversity ranged from 1.53 to 3.62 at the Eastern flank.

Table 3: Ecological indices of benthic macrofauna along Eastern Nigeria offshore

Stations	AMBI	M-AMBI	BENTIX	BI	Diversity	Richness	Disturbance Classification
ST 1	0.6	1.0	6	1	3.62	14	Undisturbed
ST 2	0.7	0.9	6	1	3.16	11	Undisturbed
ST 3	1.5	0.5	6	2	1.53	3	Slightly disturbed
ST 4	1.4	0.6	6	2	2.28	6	Slightly disturbed
ST 5	1.3	0.7	5.8	2	2.41	7	Slightly disturbed
ST 6	0.8	0.8	6	1	2.72	8	Undisturbed
ST 7	1.1	0.6	6	1	1.9	4	Undisturbed
ST 8	0.7	0.7	6	1	2.48	6	Undisturbed

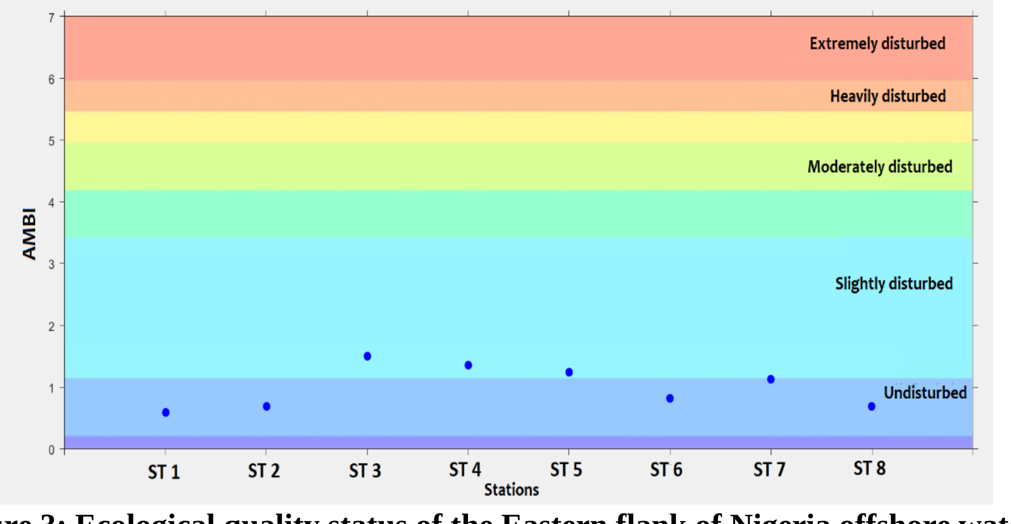
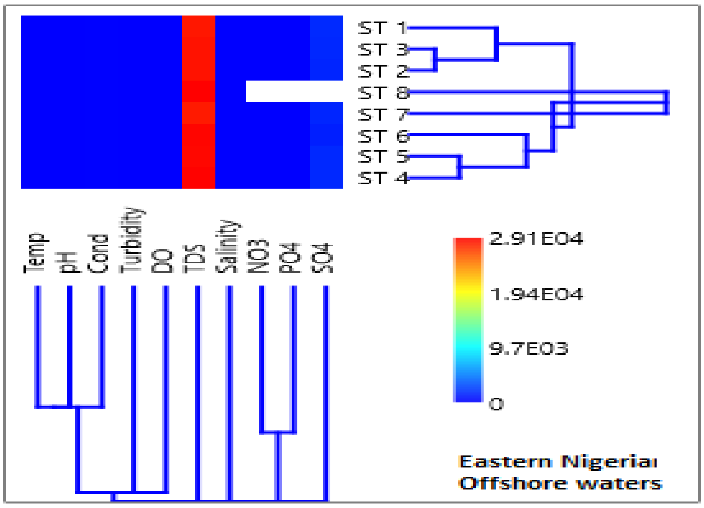


Figure 3: Ecological quality status of the Eastern flank of Nigeria offshore waters

According to the ecological quality index AMBI, the Eastern Nigeria offshore had 51.25% slightly disturbed marine environment which indicates moderate to good ecological status.

Hierarchical Cluster Analysis



The hierarchical clustering using the Bray-Curtis similarity index of the Physico-chemical parameters of Eastern Nigeria offshore are presented in Figure 4. The Bray-Curtis index showed similarities in properties and characteristics of a. temperature, pH and conductivity; b. nutrients (phosphate, nitrate and sulphate); c. dissolved oxygen (DO) and turbidity; d. Salinity and total dissolved solids (TDS) at the Eastern offshore Nigeria. At the Eastern flank, station 2 and 3; station 7 and 8; station 4 and 5 possess similar physico-chemical characteristics.

Figure 4: Hierarchical Clustering of the physico-chemical parameters at the Eastern flank Nigeria offshore

Canonical Correspondence Analysis (CCA)

The CCA recorded 66.71% and 33.21% variances at the Eastern flank in axis 1 and axis 2 respectively. CCA establishes significant relationships between the environmental variables with macrobenthic assemblages as shown in Figure 5. The environmental variable (Turbidity) had a significant impact on the distribution of Annelida at station 5; phosphate had influences on the distribution of Arthropoda at station 4; other environmental variables (DO, pH, salinity, nitrate, sulphate, conductivity and TDS) significantly influences the composition and distribution of Mollusca across the Eastern Nigeria offshore. Macrobenthic studies in marine environment have demonstrated that the distribution of macrobenthosshows a clear affinity with abiotic variables (Hossain, 2011; Selleslagh*et al.*, 2012; Nishijima*et al.*, 2015; Xie*et al.*, 2016), and this is consistent with the CCA of this study.

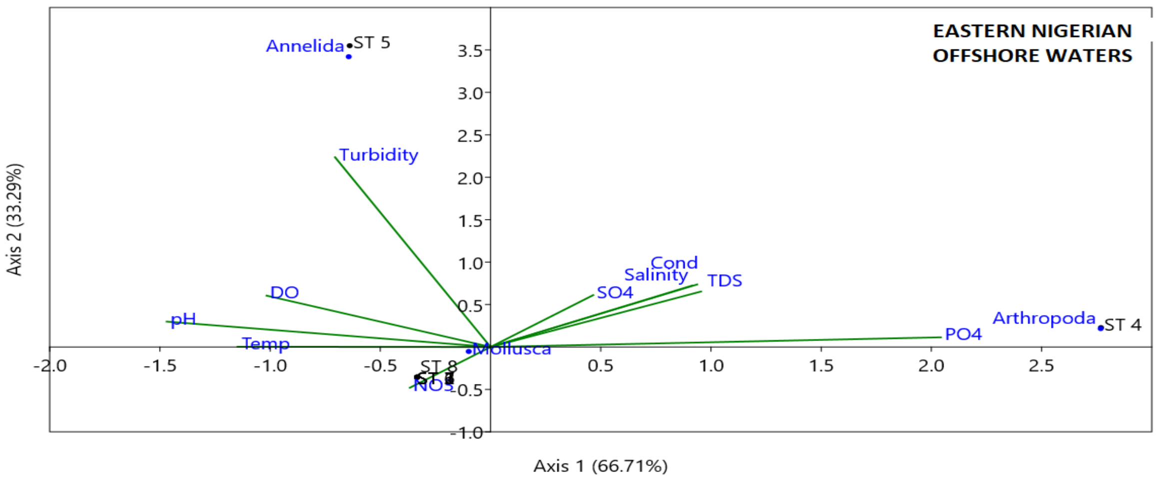


Figure 5: CCA plot of macroinvertebrate and environmental variables of Eastern Nigeria offshore

CONCLUSION

This study assessed the ecological quality status of stressors using macrobenthic communities from the Eastern Nigeria offshore. Our results indicated that the majority of Eastern offshore present a non-contaminated (undisturbed) to moderately contaminated status (slightly disturbed) marine environment which could be attributed to the oil and gas exploration and exploitation activities around the area. The outcome of these findings can support future management practices and policies in Nigeria offshore using benthic fauna as a robust bioindicator of pollution.

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Toxicological Impacts of Iron in Organs of *Synodontis clarias* and C*larias agboyiensis* from Lekki and Epe Lagoons

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ABSTRACT

High concentration of iron in aquatic environments has been a major contributing factor to aquatic pollution due to their toxicity, bioaccumulation, and potential adverse effects on a biological system. This study was undertaken to evaluate the toxicological impacts of Iron (Fe) in the organs of *Synodontisclarias* and *Clariasagboyiensis*from Lekki and Epe Lagoon. The samples were collected from these lagoons seasonally between June 2014 and April 2016. Results showedthat the measured concentrations of Iron levels in the water and organs of the sampled fish species were higher than the standard permissible limit of 0.3mg/kg. The calculated Hazard Indices (HI) in liver and gill were less than 1.0 which implies non-carcinogenic adverse effect from the consumption of the fishes. Comparatively, the Hazard index values were higher in the liver than other organs. Levels of Iron in the organs of *Synodontis clarias* and *Clarias agboyensis* in both Epe and Lekki Lagoons calls for monitoring activities within and around the lagoon to curtail further negative impact. Also, policy development towards the sustainable ecosystem health services should be advocated.

Keywords: - Iron, *Synodontisclarias*, *Clariasagboyiensis*, Heavy metal, contaminant.

INTRODUCTION

Iron is a prevalent component of industrial and mining effluents that are often discharged into aquatic environments. Ferrous iron (Fe^{2+}) is considered to be more toxic to fish than the ferric (Fe^{3+}) form. Study has shown that the highest bioconcentration of iron in fish tissues was found in the liver and gonads, and thus making the liver the target organ for iron (Omar*et al.*, 2014). Iron is an essential metal with known biological functions (Abadi *et al*., 2014) and their toxicity occurs either at metabolic deficiencies or at high concentrations (Sivaperumal *et al*., 2007). Deficiency of iron can cause an adverse health effect, whereas its high concentration can also result in negative impacts which are equivalent to or worse than those caused by non-essential metals (Kennedy, 2011). Moreover, the toxicity of iron to fish is significantly affected by the form in which they occur in water. The ionic forms of iron are more toxic than the complex inorganic or organic compound and the toxic form are more pronounced in the early stages of fish development and adversely affects various metabolic processes in the developing fish particularly the embryos which results to developmental retardation, morphological and functional deformities or death (Sfakianakis *et al*., 2015).

Toxicity of iron is due to their ability to cause oxidative damage to living tissues which includes enhanced lipid peroxidation, DNA damage, inactivation of enzyme and oxidation of protein surfydryl groups (Taiz and Zeiger, 1998). Iron toxicity can also cause cardiovascular, immunological, neurological, reproductive and developmental diseases in humans. Iron contamination may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Farombi*et al*., 2007).Iron produces toxic effects at high concentration, and thus could be considered as risk factors for several diseases (Mendil *et al*., 2010). Their toxicity could disturb the integrity of the physiological and biological mechanisms in fish that are not only an essential component, but also used as a food source (Ibrahim *et al*., 2013). Previous study has shown that marine fish, farmed fish and shellfish are significant contributors to consumer intake of iron and other contaminants due to their presence in the flesh of fish and shellfish (Rose *et al*., 2015). Thus, this study was undertaken to investigate the effects of iron on the fish health and their consequent use as bioindicators.

MATERIALS AND METHODS

Study area

The study was carried out in Lekki and Epe Lagoons, which was further sub-divided into 8 stations namely: Ibeju Town, Omu, Abejuoye, Okera-kekere, Ejirin, Oko-Orisan, Oju-alaro and Chief fish jetty.

Collection of Fish samples

The fish samples used for the study are *Synodontisclarias* and *Clariasagboyiensis.* The choice of the organisms was made based on their availability, ecological niche and sensitive response to pollutants from hotspots. The fish samples were caught using a trap net set at the bottom of the lagoon. The mean length and weight of *Synodontisclarias*and *Clariasagboyiensis*were 33.52 ± 0.22, 28.40 ± 0.25 cm and 210.06 ± 3.67 g, 185.2 ± 2.54 cm respectively.

Fish samples preparation and analysis

Blood samples were collected using sterile syringe (5 ml) followed by dissection to remove the gills, liver and gonad samples. The gills were collected by opening the operculum of the fish samples. The liver and gonad samples were dissected out of the fish through the ventral side. The liver and gonad samples were washed with normal saline solution and placed in a small plastic container with tight cover and preserved in freezer with temperature of (-20°C) until analysis (Ejimadu*et al.*, 2015). The gill, gonad and liver tissues were fixed in 10% formalin. The samples were analysed at the Anatomic and Molecular Pathology laboratory of the College of Medicine, University of Lagos Idi-Araba Lagos.

Determination of Iron in water sample

The analyses of iron were performed in accordance with APHA-AWWA-WEF, 2005, using Shimadzu Atomic Absorption Spectrophotometer (AAS)-AA 6300 model. The 1 litre water sample collected for heavy metal were fixed with 2ml of HCl for further analysis at the Nigerian Institute for Oceanography and Marine Research, Lagos.

Digestion of fish samples

Fish organs (gill, liver and gonad) were digested after dissection, according to AOAC (1990) methods. About 2.0g of partially thawed fish gill, liver and gonad were weighed into Teflon tubes and 4 ml of NHO_3 (conc.) was slowly added to the Teflon tube. The tubes were then tightly closed and placed in a stainless-steel bombs. The bombs were placed on a hot plate and heated at 110°C for one hour and then to 150°C for three hours. The samples were allowed to cool at room temperature, and the bombs were carefully open to transfer samples into 50 ml polypropylene graduated tubes in a fume chamber wearing nose gard. The tube was rinsed with deionized water three times adding the wash to the tube.

Hazard Indices

The dosages of the exposures were estimated by the expected quantities of Chromium in the ingested fish. The average daily dose (ADD) of the contaminant via the identified pathways (i.e., fish ingestion pathways) indicated the quantity of chemical substances, ingested per kilogram of body weight per day (Pacheco *et al*., 2013) that:

$$ADD = \frac{C \times IR \times ED \times EF}{Bw \times AT}$$

where C is the concentration of the contaminant in the environmental media (mg/kg); IR, the ingestion rate per unit time (0.028 mg/day); ED, the exposure duration (30 years); EF, the exposure frequency (days/year- 365); BW, the body weight of the receptor (60 kg); AT, the average time (years) equal to the life expectancy; and 365, the year-to-day conversion factor.

Hazard quotient (HQ)

Due to the exposure of harmful chemicals, toxic risks can also be referred as non-carcinogenic harms. The extent of the harm is indicated in terms of a hazard quotient (HQ):

$$HQ = \frac{ADD}{RfD}$$

where the RFD is the reference dose, the estimate of the highest dose that were taken every day over a prolonged time period without causing an adverse noncancer effect. The RFD value for ironwas 0.007 mg/kg/day, derived from USEPA-IRIS (2010) database.

Statistical Analysis

All metrics were reported as mean ± standard error (S.E), PAST Software version 3.18 (Hammer *et al.*, 2001) and statistical package SPSS 20.0 (SPSS Inc. Chicago, Illinois, USA) was used for statistical analyses. Data were analyzed by One-Way Analysis of Variance, and significant differences (*p*< 0.05) resulting from the test were reanalysed by the Duncan Multiple Range Test (DMRT).

RESULTS

The values of Iron concentration in water column from Epe and Lekki Lagoons are presented in Table 1. In each of the lagoon under consideration, the values were within the same range in both wet and dry season. The mean concentrations of Iron (Fe) in the tissues of *Synodontisclarias*and *Clariasagboyensis*with season from Epe and Lekki Lagoons are shown in Tables 2 and 3 respectively. The results obtained indicated that the values of Fe were higher in all the organs of sampled fishes from Lekki lagoon than those from Epe lagoon. The mean concentrations of average daily dose (ADD) of Iron (mg/kg) in the fish tissues with season are presented in Table 4. The values of ADD were higher in the specieClariasagboyensisthan that of*Synodontisclarias*in both season. On the other hand,the values of ADD were higher in dry season than that of wet season in the three organs for both species. the Hazard Quotient (HQ) of chromium (mg/kg) in the organs of sampled fish (Table 3), revealed that the values of HQ were within the same range in the organs of both sampled fish in the two season.

Table 1: Iron concentrations in water at Epe and Lekki lagoons

	Lekki lagoon	Epe lagoon	WHO

Heavy metal	**Wet season**	**Dry season**	**Wet season**	**Dry season**	**permissible standards**
	Mean ± S.E	**Mean ± S.E**	**Mean ± S.E**	**Mean ± S.E**	
Iron	10.657 ± 0.0001	10.642 ± 0.003	0.828 ± 0.0001	0.829 ± 0.0001	0.3

Table 2 : Bio accumulated Heavy Metals in the Organs of *Synodontisclarias* from Epe and Lekki Lagoons

Organs	**Lekki lagoon**		**Epe lagoon**		**WHO permissible standards**
	Wet season	**Dry season**	**Wet season**	**Dry season**	
Gill	41.41 ± 0.05	41.96 ± 0.05	**2.96**± 0.02	**3.01**± 0.02	0.3
Liver	**56.51**± 0.05	**57.19**± 0.05	5.21 ± 0.02	5.26 ± 0.02	0.3
Gonads	4.73 ± 0.01	4.73 ± 0.01	0.29± 0.01	0.29± 0.01	0.3

Table 3: Bio accumulated Heavy Metals in the Organs of *Clariasagboyensis*from Epe and Lekki Lagoons

Organs	**Lekki lagoon**		**Epe lagoon**		**WHO permissible standards**
	Wet season	**Dry season**	**Wet season**	**Dry season**	
Gill	44.45 ± 0.05	46.96 ± 0.05	**3.94**± 0.02	**4.41**± 0.02	0.3
Liver	**59.71**± 0.05	**60.19**± 0.05	5.21 ± 0.02	5.26 ± 0.02	0.3
Gonads	5.77 ± 0.01	5.79 ± 0.01	1.22± 0.01	1.24± 0.01	0.3

Table 4: Mean Concentrations of Average Daily Dose (ADD) of Iron (mg/kg) in the Fish Organs with Season

Organs	***SynodontisclariasClariasagboyiensis***			
	Average Daily Dose (ADD)			
	Wet	Dry	Wet	Dry
Gill	1.29×10^{-5}	2.33×10^{-5}	2.33×10^{-6}	3.17×10^{-5}
Liver	1.87×10^{-5}	2.97×10^{-5}	5.93×10^{-6}	6.07×10^{-5}
Gonads	1.38×10^{-5}	1.55×10^{-5}	1.77×10^{-6}	2.03×10^{-5}

Table 5: Mean Concentrations of Hazard Quotient (HQ) of Chromium (mg/kg) in the Fish Tissues with Season

Organs	***SynodontisclariasClariasagboyiensis***			
	Hazard Quotient (HQ)			
	Wet	Dry	Wet	Dry
Gill	0.0018	0.0033	0.0031	0.0043
Liver	0.0026	0.0042	0.0077	0.0088
Gonads	0.0019	0.0022	0.0025	0.0029

DISCUSSIONS

This research discovered that the measured concentrations of iron levels in the two lagoons were higher than the permissible limit of 0.3mg/kg (FAO, 2012), and itportends a potential danger to the consumption of fish from those lagoons. Perhaps fish accumulated iron in their organs through bioaccumulation from sediment and water column of Lekki and Epe Lagoon possibly due to anthropogenic activities in both Lagoons (Armah *et al.*, 2010). There weredifferences in the iron level across the species and seasons indicating a threat whenconsuming fish from the coastal water. Iron is an essential element in fish organs as they aid in biochemical processes as well as in storage and transport of oxygen. However, occurrence of excessive levels of iron from this study is regarded as a potential hazard which can endanger both animal and human health and this is in total agreement with the study of Iftah*et al*. (2015) who reported bioaccumulation and toxicity of Iron salt on Shingi fish *Heteropneustes fossils* and its possible impacts on human health.

Evaluation and monitoring programs for Iron bioaccumulation serve as a biomarker for fish from contaminated environment which provides information about the environmental status of an ecosystem. Thus, these biomarkers are designed for different aspects of risk assessment of an aquatic ecosystem. Nevertheless, several studies have shown that fish tissue alterations are reliable and efficient tools to detect and monitor environments that are influenced by anthropogenic activities (Adams *et al.,* 2000), which also helps to foresee potential environmental risks (Paulo *et al.,* 2012).Fish organs, such as the liver and gills, are metabolically active tissues that accumulate Iron at higher levels, as previously reported (Kennedy, 2011). Accumulation of iron in fish can be probably attributed to a response to the presence of these environmental contaminant in the ecosystems. It was observed in this research, that the stations of both lagoons were highly contaminated with Iron which accumulated in the organs of the fish species and could result to severe damages.

A recent study on toxicants in fish have clearly demonstrated that increased concentrations of iron can seriously damage the gills of fish and can results to hypertrophy, hyperplasia, gills erosion and lifting of lamellar epithelia (Mendil*et al.,* 2010). Several authors have equally reported various pathologies in relation to iron pollution in the gills of different fish species (Ibrahim*et al.,* 2013).Moreso, reduced development and morphological alterations of the gonads, including testicular oocytes, have been described in several fish species living in polluted water systems (Paulo *et al.,* 2012). The increase in iron in the liver may induce the hepatic pathological changes as observed in *Synodontisclarias*and *Clariasagboyiensis* in both lagoons. This iron can either increase or decrease hepatic enzyme activities and can lead to histopathological hepatic changes, depending on the concentration, fish species, duration of exposure and other environmental factors (Paulo *et al.,* 201).

CONCLUSION

This study evaluated the seasonal variation of iron on the organs of *Synodontisclarias* and *Clariasagboyiensis* from Epe and Lekki lagoons. Generally, results showed high level of accumulated iron in the organs of both *Synodontisclarias* and *Clariasagboyiensis* above the permissible limit of FAO. It is pertinent to constantly monitor the presence and level of anthropogenic influx of iron in the Lagoon because their continuous deposition will result to fish contamination and ultimately lead to food poisoning of the fish consumers.

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Physico-chemical Characteristics and Algal Pigments at the Makoko Creek and Okobaba Area

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ABSTRACT

Investigations into the physico-chemical characteristics and algal pigments at Makoko Creek and Okobaba area were carried out for six months between November, 2016 and April, 2017. Water samples were collected each month using 75cl plastic containers with each indicating the month of collection at the study site. Results showed monthly variations in the water quality parameters and were linked with rainfall pattern. Records were Air (31 – 35.40 ^{O}C) and water (29.40 – 32.50 ^{O}C), Salinity (2.90 – 22.03 ^{O}/o), Nutrients (Nitrate ≥ 2.22mg/L; Phosphate ≥ 0.19mg/L, Sulphate ≥ 203mg/L), alkaline pH (7.19 – 7.71), Transparency (21.50 – 74.50cm), Alkalinity (105 – 425.20mg/L), Conductivity (5439 – 36800 µS/cm), Dissolved Oxygen (5.09 – 6.57 mg/L), Chlorophyll *a* concentrations (5.50 - 19 mg/L), Chlorophyll *b* concentrations (0.20 - 1.30 mg/L) and Phaeophytin *a* concentrations (0.10 - 0.40 mg/L). Chlorophyll *a* concentrations were positively correlated with Salinity (r = -0.03), Rainfall (r = -0.60), Phosphate (r = -0.36), Sulphate (r = 0.33), Nitrate (r = -0.03), Biochemical Oxygen Demand (r = -0.4) and Dissolved Oxygen (r = -0.26). Chlorophyll *a* values were higher in months with lower precipitation which may be as a result of reduced suspended particles. The biochemical oxygen demands and nutrient values were above the regulatory standards and this could indicate that Makoko Creek is organically polluted as a result of anthropogenic activities.

Keywords: physico-chemistry, algal pigments, creeks.

INTRODUCTION

The physico-chemistry of aquatic ecosystem involves the physical and chemical parameters operating in any body of water. These parameters are very important in telling the production and productivity status or condition of a water body. They also determine biological activities and kinds of organism suited for such environments. In fact physical and chemical parameters are crucial to the survival of marine organisms (Varadharajan and Soundarapandian, 2014). Creeks are common hydrological features in the South-Western Nigeria and in this region they gravitate to coastal lagoons in their immediate area enroute to the sea via the Lagos harbor. The physico-chemical characteristics of any aquatic ecosystem and the nature and distribution of its biota are directly related to and influenced by each other and controlled by a multiplicity of natural regulatory mechanisms. However, because of man's exploitation of the water resources, the normal dynamic balance in the aquatic ecosystem is continuously disturbed, and often results in each dramatic response as depletion of fauna and flora, fish kill, change in physico-chemical character etc (Lee, 1999). Planktons have been diagnostic in assessing water quality and hydrological status. They qualify as suitable indicators in that they are simple, capable of quantifying changes in water quality, applicable over large geographic areas and can also furnish data on background conditions and natural variability (Lee, 1999). Biological communities respond to stresses over time, thereby, they provide information that a more rapidly- changing water chemistry measurements or toxicity tests do not always produce. As such, biological assessment provides a more reliable assessment of long-term biological changes in the condition of the water body. Therefore, this paper was aimed at investigating the algal pigments concentrations in the Makoko and Okobaba Creek of Lagos lagoon in relation to seasonal fluctuation and its physico-chemical parameters.

MATERIALS AND METHODS

Study Area

Two stations were selected and sampled for a period of six months, the Makoko creek and the Okobaba area . The Makoko creek is an adjoining creek to the Lagos lagoon and part of the Lagos lagoon complex in the southern part of Nigeria The Global Positioning System location for the site was (Latitude 6.49N and Longitude 3.38E). Okobaba creek of Lagos lagoon is impacted of sawmilling activities from the Okobaba sawmill hub. The Global Positioning System for the experimental site was Latitude $6°29^{1}25.57^{11}$N and Longitude $3°23^{1}34.20^{11}$E. The Okobaba sawmill industry is situated at Ebute Meta, in the Mainland of Lagos State, near the Third mainland Bridge.

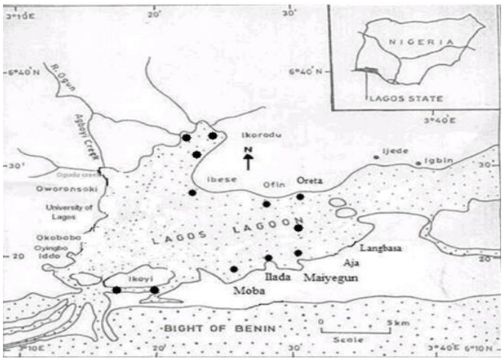

Fig 1. Map of Lagos Lagoon Showing the Study Area

Water Collection

Water samples were collected for water chemistry analysis in well labeled 75cl plastic containers with screw cap at the surface of the water body. The sample bottles were screwed tight, kept upright and transported to the laboratory for further analysis.

Plankton Collection

Plankton samples were collected using a plankton net of 55 µm mesh size, hauled horizontally on a motorized boat and towed at low speed (<4 knots) for five minutes. The collected samples were concentrated and stored in 500 ml plastic jars with screw caps, and preserved in 4% unbuffered formalin.

Physicochemical Analysis

Air and surface water temperatures (°C) were measured with a mercury-in-glass thermometer; salinity was determined using saline test meter (Hanna Instrument HI 98203; pH was measured in the laboratory using the electrometric method using the Cole Parmer Test; dissolved oxygen (mg/L) was estimated by the Titrimetric method using the Azide Modification procedure 4500°C (APHA, 2005).

Statistical Analysis

Data generated were analyzed using descriptive and inferential statistics such as Principal Components Analysis (PCA), Canonical Correspondence Analysis (CCA), Nutrient stoichiometry and Pearson's correlation coefficient.

RESULTS AND DISCUSSION

Monthly variations in the physico-chemical parameters as well as chlorophyll *a*, chlorophyll *b* and phaeophytin *a* values at Makoko (Station1) and Okobaba creek (Station 2) between November, 2016 and April, 2017 with the mean and standard deviation values are presented in Table 1.

S/N	PARAMETERS	NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		APRIL		Min.		Max.		Mean	
		St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St.2	St.1	St.2	St.1	St.2
1	**Air temperature (ºC)**	34.00	32.50	34.00	33.00	34.00	35.40	32.10	31.10	31.00	34.00	32.00	32.00	31.00	31.10	34.00	35.40	32.85	33.00
2	**Water temperature (ºC)**	30.50	31.00	31.50	32.00	29.40	30.20	30.00	30.50	32.00	32.00	31.20	32.50	29.40	30.20	32.00	32.50	30.77	31.37
3	**Rainfall (mm)**	37.80		2.10		80.60		0.00		110.60		125.80		0.00		125.80		59.48	
4	**Transparency**	32.50	43.50	28.00	46.00	27.50	74.50	21.50	46.50	25.50	71.00	41.50	56.50	21.50	43.50	41.50	74.50	29.42	56.33
5	**pH @ 25°C**	7.35	7.44	7.26	7.30	7.19	7.23	7.24	7.42	7.58	7.71	7.41	7.37	7.19	7.23	7.58	7.71	7.34	7.41
6	**Conductivity (µS/cm)**	5430.00	7380.00	19200.00	21100.00	22800.00	29800.00	31900.00	34000.00	28800.00	36800.00	24700.00	29600.00	5430.00	7380.00	31900.00	36800.00	22138.33	26446.67
7	**Total Suspended Solids (mg/L)**	15.00	43.00	11.00	12.00	29.00	22.00	13.00	10.00	11.00	9.00	13.00	8.00	11.00	8.00	29.00	43.00	15.33	17.33
8	**Total Dissolved Solids (mg/L)**	3312.00	4502.00	10752.00	11816.10	13930.80	18207.80	19459.00	20740.20	17568.00	22448.00	15067.00	18056.00	3312.00	4502.00	19459.00	22448.00	13348.13	15961.68
9	**Salinity (ppt)**	2.90	3.91	10.80	12.04	13.14	17.50	18.90	20.20	16.82	22.03	14.32	17.40	2.90	3.91	18.90	22.03	12.81	15.51
10	**Acidity ($mgCaCO_3/L$)**	70.10	22.00	24.00	10.00	66.30	60.00	6.10	4.00	6.50	5.30	12.70	9.90	6.10	4.00	70.10	60.00	30.95	18.53
11	**Alkalinity ($mgCaCO_3/L$)**	168.30	105.00	180.10	114.00	425.20	240.00	190.00	150.00	240.00	160.30	248.70	155.90	168.30	105.00	425.20	240.00	242.05	154.20
12	**Total Hardness ($mgCaCO_3/L$)**	551.00	589.10	1962.00	2107.40	2470.30	3294.10	3592.60	3839.80	3193.10	4181.80	2703.10	3284.50	551.00	589.10	3592.60	4181.80	2412.02	2882.78
13	**Dissolved Oxygen (mg/L)**	5.81	5.09	5.67	5.71	6.33	6.51	6.50	6.54	6.57	6.46	6.33	6.41	5.67	5.09	6.57	6.54	6.20	6.12
14	**Bichemical Oxygen $Demand_5$ (mg/L)**	2.00	7.00	2.00	2.00	3.00	1.00	2.00	1.00	2.00	1.00	3.00	1.00	2.00	1.00	3.00	7.00	2.33	2.17
15	**Chemical Oxygen Demand (mg/L)**	11.00	28.00	5.00	6.00	5.00	3.00	5.00	3.00	3.00	3.00	7.00	2.00	3.00	2.00	11.00	28.00	6.00	7.50
16	**Chloride (mg/L)**	1590.10	1701.30	5945.00	6606.00	7231.50	9630.00	10398.80	11114.00	9243.40	12104.50	7876.00	9570.50	1590.10	1701.30	10398.80	12104.50	7047.47	8454.38
17	**Nitrate (mg/L; as NO_3)**	8.33	2.22	15.95	11.08	9.75	8.86	9.31	4.43	8.99	5.72	4.31	7.87	4.31	2.22	15.95	11.08	9.44	6.70
18	**Sulphate (mg/L)**	203.00	217.20	820.00	910.00	1023.20	1362.80	1323.00	1410.00	1176.20	1540.30	973.80	1183.30	203.00	217.20	1323.00	1540.30	919.87	1103.93
19	**Phosphate (mg/L)**	0.19	0.24	1.17	0.61	30.40	4.91	1.32	0.29	3.19	0.29	3.60	0.29	0.19	0.24	30.40	4.91	6.65	1.11
20	**Silica (mg/L; as SiO_2)**	2.90	6.80	3.13	3.30	1.32	2.72	1.59	0.74	3.51	1.19	4.57	1.70	1.32	0.74	4.57	6.80	2.84	2.74
21	**Calcium (mg/L)**	32.70	35.10	116.11	129.10	147.30	196.18	213.57	228.26	188.59	248.58	158.95	193.14	32.70	35.10	213.57	248.58	142.87	171.73
22	**Magnesium (mg/L)**	113.02	120.90	406.00	455.10	513.77	684.25	742.77	793.80	660.01	864.60	559.91	680.34	113.02	120.90	742.77	864.60	499.25	599.83
23	**Sodium (mg/L)**	893.02	954.10	3198.03	3588.12	3991.99	5321.15	5821.20	6221.61	5175.01	6776.00	4396.24	5341.80	893.02	954.10	5821.20	6776.00	3912.58	4700.46
24	**Potassium (mg/L)**	29.22	31.10	102.04	114.20	134.34	180.22	192.72	206.04	171.40	224.44	143.20	174.02	29.22	31.10	192.72	224.44	128.82	155.00
25	**Zinc (mg/L)**	0.05	0.06	0.06	0.06	0.05	0.05	0.06	0.06	0.06	0.07	0.06	0.06	0.05	0.05	0.06	0.07	0.06	0.06
26	**Iron (mg/L)**	0.09	0.09	0.10	0.10	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.08	0.07	0.07	0.10	0.10	0.09	0.08
27	**Copper (mg/L)**	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.00	0.00	0.00	0.00	0.00
28	**Cadmium (mg/L)**	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.00	0.00	0.00	0.00	0.00
29	**Lead (mg/L)**	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.00	0.00	0.00	0.00	0.00
30	**Chromium (mg/L)**	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.00	0.00	0.00	0.00	0.00
31	**Manganese (mg/L)**	0.05	0.06	0.03	0.04	0.04	0.05	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.02	0.05	0.06	0.03	0.04
32	**Nickel (mg/L)**	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.001	0.001	0.00	0.00	0.00	0.00	0.00	0.00
33	**Chlorophyll *a* (µg/L)**	19.00	9.30	7.30	8.20	11.30	7.20	7.90	16.40	11.20	7.60	5.50	8.10	5.50	7.20	19.00	16.40	10.37	9.47

34	**Chlorophyll *b* (µg/L)**	1.30	0.70	0.60	0.50	0.70	0.30	0.40	0.50	0.60	0.40	0.30	0.20	0.30	0.20	1.30	0.70	0.65	0.43
35	**Phaeophytin *a* (µg/L)**	0.40	0.20	0.20	0.30	0.20	0.10	0.20	0.20	0.30	0.20	0.10	0.10	0.10	0.10	0.40	0.30	0.23	0.18
36	**Dissolved Inorganic Nitrogen (mg/L, as N)**	1.88	0.50	3.64	2.55	10.40	1.69	0.44	0.10	1.06	0.10	1.20	0.10	0.44	0.10	10.40	2.55	3.10	0.84
37	**Dissolved Organic Nitrogen (mg/L, as N)**	0.04	0.03	0.11	0.10	2.21	2.10	2.10	1.00	2.03	1.29	0.97	1.78	0.04	0.03	2.21	2.10	1.24	1.05
38	**Dissolved Inorganic Phosphorus (mg/L, as P)**	0.06	0.08	0.39	0.20	0.11	0.11	0.40	0.07	0.11	0.07	0.10	0.08	0.06	0.07	0.40	0.20	0.19	0.10
39	**Oil & Grease (mg/L)**	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

DISCUSSIONS

The occurrence of phytoplankton in the Makoko and Okobaba creek cannot be considered alone but in relation to the prevailing environmental conditions particularly physicochemical parameters (Kadiri, 2006). Occurrence of phytoplankton alliances of pollution status of the water body. The regime of ecological characteristic operating in the Lagos lagoon has been documented by authors (Emmanuel and Onyema, 2007). The Makoko creek is an adjoining creek to the Lagos lagoon and part of the Lagos lagoon complex in the southern part of Nigeria. It is a place with high anthropogenic influence which is highly polluted with raw sewage, household wastes and human wastes. Okobaba creek of Lagos lagoon is a water body that is presented to direct impact of sawmilling movement and other local wellsprings of contamination of the water body. High air and water temperatures recorded during the study are typical for the region (Nwankwo and Onyema., 2003). Air temperature was higher in dry months for the two stations. These observations may be due to increased insolation due to lower cloud cover, and cessation of rainfall as previously reported by Nwankwo, (2004), Onyema, (2007) and Nwankwo and Amuda (1993). The water temperature didn't change steadily with the dry months, which could be as a result of water's high heat retaining capacity. During the study there was a direct relationship between Total Dissolved Solids (T.D.S), Total Suspended Solids (T.S.S), Transparency and Rainfall. In the dry months T.S.S was low possibly due to low flood water inflow to the creek. The salinity values recorded at the sites ranged from 2.90 to 18.90‰ in Station 1 and 3.91 to 22.03‰ in Station 2 which is high, representing a brackish condition. The increase in salinity in dry month could be due to increased evaporation and reduction of flood water at the cessation of rain. However, the lowest salinities were recorded in the month of November in both Stations because salinity regimes in the Lagos lagoon is seasonal, with high salinities reported from December to April and low salinities observed between May and November (Hill and Webb, 1958; Nwankwo, 1996 and Onyema et al., 2005). The creeks exhibited the usual alkaline properties with pH values ranging between 7.19 and 7.58 in Station 1 and 7.23 and 7.71 in Station 2. This is in agreement with Nwankwo and Akinsoji (1992) for tidal creeks in Lagos that are slightly alkaline. The Total hardness, Calcium ions and Chloride ions significantly reduced in the wet months as a result of increase in flood water. The lower total hardness of the water in the wet months could be as a result of dilution by flood waters. The dissolved oxygen concentration recorded at the sites may be associated with the effect of increased water temperature and increased microbial activities in the dry months. Nwankwo and Akinsoji (1988) reported that dissolved oxygen decreased in the Lagos lagoon benthos with increased temperature and bacterial activity. According to Nwankwo,

(2004), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) can be employed in determining water quality. Biochemical oxygen demand value greater than 8mg/L reflects a high level of pollution. The biochemical oxygen demand observed for both Stations ranged between 1 and 7mg/L possibly indicating a moderately polluted environment which could be associated with the discharge of solid wastes, wood wastes and household wastes. The high availability of nutrients (nitrate, phosphate, silicate and sulphate) may have encouraged the growth and abundance of phytoplankton. The high levels of these nutrients may be due to the direct discharge of wastes into the creek from anthropogenic and household sources.
The heavy metal concentration was at trace levels (Copper: 0.001- 0.002mg/L and Zinc: 0.05-0.06mg/L in Station 1 and 0.05-0.07mg/L in Station 2, Iron: 0.07- 0.099 in Station 1 and 0.06-0.098 in Station 2). During the period of study oil and grease values were also recorded. Slight values of these could be attributed to boating activities, the saw mill and commercial activities in the study sites. Chlorophyll *a* measurement showed an increase in dry months which may be as a result of reduced suspended particles leading to an increase in light penetration. However, the highest value of chlorophyll *a* concentration was recorded in the wet month ($19.00\mu g/L$) at Station1 which could be due to the water being slightly transparent at the period of sampling. Chlorophyll *a* concentration observed at the creek exhibited significant negative correlations with salinity. The decrease in chlorophyll content at higher salinity might possibly be due to changes in the lipid protein ratio of pigment-protein complexes or increased chlorophyllase activity and may also be that the species, representing phytoplankton biomass are intolerant to salinity. Chlorophyll *a* concentration increased with reduction in Dissolved oxygen which maybe as a result of increased phytoplankton growth and microbial activities which makes nutrients available for the uptake of these organisms. Chlorophyll *a* increased as Chemical oxygen demand increased which may be associated with the availability of Carbon dioxide from the oxidation of organic matter in the water (Boyd, 1973). Chlorophyll *a* and Phaeophytin *a* concentration showed a direct relationship with nutrient (nitrate, phosphate, silicate and sulphate) levels which may be due to increased phytoplankton growth as a result of nutrient availability. It is a place with high anthropogenic influence which is highly polluted with raw sewage, household wastes and human wastes. Okobaba creek of Lagos lagoon is a water body that is presented to direct impact of sawmilling movement and other local wellsprings of contamination of the water body. High air and water temperatures recorded during the study are typical for the region. Air temperature was higher in dry months for the two stations. These observations may be due to increased insolation due to lower cloud cover, and cessation of rainfall as previously reported by Nwankwo and Onyema (2007). The water temperature didn't change steadily with the dry months, which could be as a result of water's high heat retaining capacity.

CONCLUSION

The physico-chemical parameters at the Makoko and Okobaba creek suggest the dominance of anthropogenic wastes such as raw sewage, wood wastes, domestic waste, industrial effluents, and the inflow of pollutant-laden water on land-based sources (Onyema, 2007). Salinity usually varies drastically between rainy and dry seasons; as such, the existence of an environmental gradient can be linked with rainfall pattern in the Lagos lagoon

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Aflatoxin, and heavy metal load in *Scomber scombrus* and *Clupea harengus* from two selected coldroom facilities in Kwara State, Nigeria

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ABSTRACT

Impurities found in fish have been a major cause of disease and illness to consumers. This study's objective was to evaluate the total aflatoxin, and heavy metal load in two frozen fish: *Scomber scombrus* and *Clupea harengus* from two (2) cold room facilities in Omu-aran and Ilorin. 5 kg fish samples each was bought per carton of 20 kg of *Scomber scombrus* and *Clupea harengus* per time for three months. Heavy metal load and total aflatoxin was investigated using standard methods. Health risk was also determined using Health Risk Index HRI), Daily intake of Metals (DIM), and health quotient (HQ), and Total toxicity of metals (TTM). Cd, Cu, Ni, Pb, Mn and Cr were not significantly different (p>0.05) in both species from both locations. Nickel was lower than the recommended limit by WHO. Level of Mn and Cr were higher in both species. Mn load was higher in the muscles (1.037, 1.187, 0.830) ppm than in the gills (0.509, 0.518, 0.550) ppm all through the months. Cr was higher in the gills (0.794, 0.856, 0.881) ppm than muscles (0.445, 0.350, 0.288) ppm all through the months. HRI was > 1 in the different age groups for the different metals. TTM was > 1 in both species. Total aflatoxin level was highest in the gills (4.25 – 5) ppb than in the muscle (1.5 - 3) ppb for both locations respectively. The study concludes that heavy metal loads (Mn, Cd, Cu, Cr, and Ni) were more than the permitted limitations imposed by FAO, WHO and EU legislation for fish and fish products placing consumers at health risk.

Keywords: Aflatoxin, Heavy metals, *Scomber scombrus*, *Clupea harengus*

INTRODUCTION

In Nigeria, fish is recognized and cherished as one of the healthiest, safest and one of the cheapest sources of protein (Ukoha et al., 2014) adding about 17% of the protein intake (Boyd et al., 2022), with per capita consumption of 20.2 kg per annum in 2020, and a total consumption of 157 million Mt (FAO, 2022). In Nigeria, fish importation according to the Minister of Agriculture and Rural Development accounts for about 75% of the total consumption. White croaker (*Umbrina canosai*),

African mackerel (*Scomber scombrus*), and herrings (*Clupea harengus*) are three (3) popular frozen fish in the Nigerian markets (Linnaeus 1788), and they make up a sizable portion of the imported fish consumed in Nigeria. However, water body pollution due to the presence of heavy metal has grown to be a significant public health and environmental concern.
Nigeria has many public frozen fish sales outlets and retail marketplaces spread out around the nation, where a sizable number of people regularly purchase frozen seafood items. According to Bintsis (2017), perhaps the most pervasive health issue of our time is foodborne disease, which also contributes significantly to lower economic output. Numerous elements, including Sodium (Na), Potassium (K), Iron (Fe), Calcium (Ca), Boron (B), Magnesium (Mg), Selenium (Se), Copper (Cu), and Zinc (Zn) are present in both the fish and its surroundings. For the maintenance of biological activities, these substances are necessary in very small amounts. Most metals are naturally occurring components of the earth's crust. In addition to being naturally present in fish and its surroundings, as a result of human activity, such as agricultural and manufacturing processes, metals and other elements may also find their way into food (Briffa et al., 2020). The World Health Organization (WHO) as well as the Food and Agriculture Organization of the United Nations (FAO) listed eight (8) elements that are present in fish that requires constant monitoring. They include; Mercury (Hg), Cadmium (Cd), Lead (Pb), Arsenic (As), Copper (Cu), Zinc (Zn), Iron (Fe), and Selenium (Sn), while screening of others—while not required—might be advantageous (Simpson & Uche, 2019).
In order to assess the amount of heavy metals present in two commonly consumed imported frozen fish bought from cold room facilities in Ilorin and Omu-Aran, Kwara State, this research was carried out. Also, the microbial load and total aflatoxin of the species were investigated. The detrimental effects on human health from eating such fish was also assessed.

MATERIALS AND METHODS

Purchase of fish

Fish samples were purchased from two cold rooms in Ilorin and Omu-Aran, Kwara State, Nigeria. 5 kg fish samples each was bought per carton of 20 kg of the various forms (*Scomber scombrus* Linnaeus, 1758 and *Clupea harengus* Linnaeus, 1758) per time. Fish samples were kept in an ice chest and transported to the wet laboratory of the Department of Animal Science, Landmark University, Omu-Aran, Kwara State, Nigeria. The preference for the species led to the selection of fish species for the study. Purchase was done once every third week of the month, for three months (September, October and November). This is because the cold rooms' operators informed that new batch of importation arrived at such interval most of the times.

Laboratory procedure

Using a Camry electronic weighing scale (Model EK3250.5kg), the weight of the fish samples was determined to the nearest 0.1 g. The frozen fish samples were rinsed with clean water. Before digestion, fish gills and muscles were removed, and each item was preserved individually in well-marked plastic bags.

Digestion of fish samples

This study used a wet acid digestion method (Raimi et al., 2019). Gills and muscle (0.5g each) were collected from each samples, blended using an electronic blender (Binatone BLG-595 MK2) and kept in a beaker. To the blended sample, 4 ml of nitric acid was added. The beaker containing the mixture was then placed on a hot plate for 15 minutes until the solution became clear, and was made up to 50 ml using distilled water and poured into sterile bottles until use.

Fish digest was exposed to Atomic Absorption Spectrophotometry (AAS) (Model 211 VGP Buck Scientific) for heavy metal analysis using the calibration plot technique (Adedire et al., 2021) at Afe Babalola University, Ado-Ekiti, Nigeria. The instrument was auto-zeroed for each element using the blank (distilled water), and then the standards were aspirated into the flame from lowest to highest concentration. The apparatus measured the corresponding absorbance, and a graph of absorbance against concentration was drawn. The samples were analyzed with the concentration of the metals present being displayed in parts per million (ppm) after extrapolation from the standard curve.

Total aflatoxin in sampled fish

Total aflatoxin test protocol was carried out as described in the Romer labs test kits with slight modification. Five (5) g of the fish sample was weighed and was added to 25 mls of 70% methanol and left for 10 minutes for extraction of aflatoxin. Then the mixture was filtered using a No. 1 Whatman filter paper. A ⅒ dilution was then made by adding 100 µl of the filtrate to 900 µl of 70% methanol. 50 µl of the diluent and 100 µl of conjugate was then dispensed into the green-bordered well. 100 µl from the filtrate-conjugate mixture was taken and dispensed into the antibody coated wells and incubated at room temp for 15 minutes. The content of the well was then discarded and washed with distilled water 3 times. 100 µl of substrate was added to the well and incubated for 5 minutes and observed for color change (different shades of blue to colorless) after which a 100 µl of stop solution was added and the plates were read with ELISA plate reader at 450 nm wavelength. Optical density of the samples was recorded and multiplied by 10.

On Microsoft Excel, a graph was plotted of the standard concentrations versus optical densities. From this graph, extrapolations were made to determine levels of total aflatoxin in fish samples.

Risk assessment

Using hazard quotient (HQ), risk evaluation was conducted to measure the danger presented by human consumption of tainted seafood (Khan et al., 2006), health risk index (HRI) according to methods by (Abubakar et al., 2015) total toxicity of mixtures (TTM) index (ANZECC & ARMCANZ, 2000) and daily intake of metal (DIM) (Okunola et al., 2011).

Hazard Quotient (HQ)

HQ was determined using the equation

$$\mathrm{HQ} = \frac{Wfish * Mfish}{RfD * \ Bo})$$

Where,

Wfish = daily dry weight of fish that is eaten (gd-1). For nutritional needs, a daily consumption of 20.9 grams of fish per adult with an average body weight of 79.96 kilograms and older, 10.1 grams per child with an average body weight of 49.7 kilograms and below, and 6.2 grams per person with a body weight of 17.3 kilograms was advised (aged range 0years – 9years).

Mfish = metal concentration in fish (mgkg-1),

RfD = metal reference dose (mgkg-1d-1); RfD used; Iron (Fe) (0.7), Manganese (Mn) (0.014), Zinc (Zn) (0.3), Copper (Cu) (0.04), Nickel (Ni) (0.02), Cadmium (Cd) (0.001).

Bo = average body weight (kg)

3.6.2 Daily Intake of Metals (DIM)

The DIM formula was developed to estimate the daily loading of metals into the human system from fish intake.

$$\mathrm{DIM} = (Cmetal \frac{Dfish}{Bo})$$

Where,
Cmetal = concentration of heavy metals in the fish (mgkg-1),
Dfish = daily nutritional intake of fish (gday-1),
Bo = average body weight (Kg)

Health Risk Index (HRI)

The Health Risk Index (HRI) was calculated using the formula below.

$$\text{HRI} = \frac{DIM}{RfD}$$

A Health Risk Index (HRI) value of less than one (1) denotes a safe exposure to such a heavy metal and is regarded as acceptable; otherwise, the fish may be at danger for exposure to heavy metals.

Total Toxicity of Mixtures (TTM)

Total Toxicity of Mixtures (TTM) for heavy metals was determined by applying the TTM index.

$$\text{TTM} = \Sigma(1\frac{Ci}{GVi})$$

Where:
Ci = Concentration of the 'ith' component of mixture
GVi = Value to use as a guide for the 'ith' component. values that should be used as triggers for low-risk livestock water consumption. Iron not enough hazardous, Lead 0.1 mg/L, Manganese not sufficiently toxic, Nickel 1 mg/L, Zinc 20 mg/L, Cadmium 0.01 mg/L, Chromium 1 mg/L, Copper 0.4 - 5 mg/L.
TTM >1= The mixture was shown to be above the Guideline value

Statistical Analysis

The Statistical Analytical Standard (SAS) was applied to all the data. The differences in the heavy metal concentration of the two fish species were ascertained using one-way and two-way analysis of variance (ANOVA).

RESULTS

Heavy metals in sampled fish

Table 1 showed the concentrations of specific metals in the fish that were sampled. Levels of all the heavy metals showed that there was no significant difference in both species of the sampled fish (p>0.05). Mn and Cr were higher in both species.

Table 1: Heavy metals in the fish species

Heavy Metals	African Mackerel	Frozen Herrings	Standard Deviation	Permissible limits
Cd	0.01^a	0.01^a	0.01	0.0000001
Cu	0.290^a	0.290^a	0.10	0.000003
Cr	0.594^a	0.609^a	0.33	0.03
Mn	0.804^a	0.742^a	0.31	0.000025
Ni	0.005^a	0.006^a	0.01	0.05
Pb	0.024^a	0.027^a	0.02	0.00007

Means with different superscript in same row are significantly different (p>0.05).

Metal load in organs of sampled fishes

Tables 2a-c showed the burden of these substance in the gills and muscles of sampled fish for Three (3) consecutive months. Mn load was higher in the muscles of the fish than in the gills all through the months. Significant variation at 95% probability was observed in all the heavy metals across the three months of purchase of the sampled fish.

Table 2a: Metal load (ppm) in gills and muscles of sampled fishes in September

Metals	Gill	Muscle	Standard deviation
Mn	0.509^{b}	1.037^{a}	0.09
Cu	0.277^{a}	0.166^{b}	0.04
Cr	0.794^{a}	0.445^{b}	0.12
Cd	0.011^{a}	0.003^{b}	0.00
Pb	0.041^{a}	0.013^{b}	0.01
Ni	0.006^{a}	0.002^{b}	0.00

Means with different superscript in same row are significantly different (p<0.05)

Table 2b: Metal load (ppm) in gills, and muscles of sampled fishes in October

Metals	Gill	Tissue	Standard deviation
Mn	0.518^{b}	1.187^{a}	0.14
Cu	0.309^{a}	0.180^{b}	0.05
Cr	0.856^{a}	0.350^{b}	0.17
Cd	0.014^{a}	0.007^{b}	0.01
Pb	0.047^{a}	0.008^{b}	0.01
Ni	0.006^{a}	0.003^{b}	0.01

Means with different superscript in same row are significantly different (p<0.05)

Table 2c: Metal load (ppm) in gills, and muscles of sampled fish in November

Metals	Gill	Tissue	Standard deviation
Mn	0.550^{b}	0.830^{a}	0.17
Cu	0.326^{b}	0.420^{b}	0.06
Cr	0.881^{a}	0.288^{b}	0.25
Cd	0.025^{a}	0.009^{b}	0.01
Pb	0.038^{a}	0.008^{b}	0.01
Ni	0.009^{a}	0.005^{b}	0.01

Means with different superscript in same row are significantly different (p<0.05)

Metal load in the organs of fish species

Comparison of the heavy metal load in the gills and muscles of the species showed no significant difference (p>0.05) in the gills and muscles of both species. The highest level of Mn and Cr, were observed in the muscles and gills of both species Table 3a. Table 3b shows the heavy metal load in the two (2) species from the different markets.

Table 3a: Heavy Metals in the organs of fish species

Organs	Species	Metals (ppm)					
		Mn	**Cu**	**Cr**	**Cd**	**Pb**	**Ni**
Gills	***S. scombrus***	0.512±0.14	0.0304±0.04	0.892±0.28	0.018±0.01	0.045±0.02	0.008±0.01
	C. harengus	0.546±0.13	0.313±0.07	0.816±0.25	0.017±0.01	0.040±0.02	0.007±0.01
Muscle	***C. harengus***	0.972±0.20	0.277±0.13	0.326±0.10	0.005±0.00	0.010±0.01	0.003±0.00
	S. scombrus	1.056±0.24	0.270±0.14	0.363±0.08	0.009±0.01	0.008±0.01	0.004±0.01

Means±SD with different superscript in same row are significantly different ($p<0.05$)

Table 3b: Heavy Metals in the sampled fish from different markets

Location	Species	Metals (ppm)					
		Mn	**Cu**	**Cr**	**Cd**	**Pb**	**Ni**
Omu-aran	***S. scombrus***	0.750±0.31	0.294±0.08	0.696±0.38	0.014±0.01	0.031±0.02	0.006±0.00
	C. harengus	0.809±0.32	0.310±0.10	0.600±0.32	0.014±0.01	0.022±0.02	0.003±0.00
Ilorin	***S. scombrus***	0.734±0.27	0.287±0.11	0.522±0.31	0.009±0.01	0.023±0.02	0.005±0.00
	C. harengus	0.793±0.32	0.275±0.11	0.579±0.27	0.011±0.01	0.026±0.02	0.008±0.01

Means±SD with different superscript in same row are significantly different ($p<0.05$)

Risk assessment index of metals

Table 5 showed calculated health quotient (HQ), daily intake of metal (DIM), and health risk index (HRI) for different age groups. HRI was >1 in all the age categories. Total toxicity of metals (TTM) was >1 for the metals (Table 6).

Table 4: HQ, DIM and HI for individual responses to heavy metal accumulation in fish samples ($mgkg^{-1}$)

Species	Metals	Mean±SD (ppm)	DIM (Age categories)			HQ (Age categories)			HRI (Age categories)		
			A	B	C	A	B	C	A	B	C
S. scomber	Cd	0.010±0.01	0.01	0.05	0.028	2.61	2.03	3.58	10.0	50.0	28.0
	Cu	11.29±1.11	0.08	1.43	0.81	1.895	1.47	2.598	2.0	35.75	20.25
	Cr	0.10±0.00	0.16	2.92	1.66	5.18	4.02	7.09	5.33	97.33	55.33

	Mn	1.10±0.12	0.21	3.96	2.24	15.01	11.7	20.6	15.0	282.86	160.0
	Ni	0.25±0.03	0.001	0.025	0.014	0.065	0.051	0.089	0.05	12.5	0.70
	Pb	8.36±1.78	0.006	0.12	0.067	0.018	0.014	0.025	0.017	0.34	0.19
C. harengus	Cd	0.33±0.12	0.003	0.05	0.028	2.61	2.03	3.58	3.00	50.0	28.0
	Cu	5.80±1.57	0.08	1.43	0.81	1.895	1.47	2.598	2.0	35.75	20.25
	Cr	0.08±0.01	0.09	1.62	0.92	5.31	4.13	7.28	3.0	54.0	30.67
	Mn	1.17±0.42	0.19	3.65	2.07	13.85	10.77	19.0	13.57	260.71	147.86
	Ni	0.01±0.1	0.002	0.030	0.017	0.078	0.061	0.108	0.1	1.5	0.85
	Pb	0.01±0.01	0.007	0.132	0.0075	0.020	0.016	0.028	0.02	0.38	0.021

A = adults age 20years and above. B = children age 10 years – 19 years. C = children age 0 – 9 years

Table 5: TTM for individual responses to heavy metal accumulation in fish samples

Species	Metals	Mean±SD (mgkg-1)	Guideline value (mg/L)	Ci/Gvi	TTM
S. scombrus	**Cd**	0.010±0.01	0.01	1.00	
	Cu	11.29±1.11	5.0	0.058	
	Cr	0.10±0.00	1	0.594	1.897
	Ni	0.25±0.03	1	0.005	
	Pb	8.36±1.78	0.1	0.24	
C. harendus	**Cd**	0.33±0.12	0.01	1.00	
	Cu	5.80±1.57	5.0	0.058	
	Cr	0.08±0.01	1.0	0.609	1.943
	Ni	0.01±0.1	1.0	0.006	
	Pb	0.01±0.01	0.1	0.27	

Total aflatoxin in sampled fish organs

Aflatoxin levels in the organs of the sampled fishes from both markets revealed that there was no significant difference ($p>0.05$). Highest levels of aflatoxin were recorded in the gills of fishes from the markets Table 6.

Table 6: Aflatoxins level in sampled fish

LOCATION	GILLS (ppb)	MUSCLES (ppb)
Omu-aran	5	1.5
Ilorin	4.25	3

Microbial load in sampled fishes

Table 7a shows the bacteria and fungi found in the muscles of the experimental fish. 2 cfu/100µl and 80 cfu/100µl of the coliform and non-coliform bacteria were present in *S. scombrus* bought from Omu-aran market in the month of September Table 7a. Other bacteria identified include *Enterobacter intermedius* and *Shigella sonnei*. Coliform and non-coliform bacteria load in the month of November were observed to be higher to too numerous to count in both species. Table 7b.

DISCUSSION

The concentration of Manganese observed in this study to have exceeded the recommended permissible limit for fish and fish products 2.50 mg/kg according to (Skovgaard, 2003) is an indication of the state of the water from which the fish was captured. This report is however at variance with the study by (Benzer et al., 2013). Differences could be attributable to the differences in location from which the sampled species were obtained. The levels of Mn in the analyzed fish are beyond the risk limit for humans and therefore poses to be a source of danger to people's health, according to the HRI value of Mn, which was > 1 in all age classifications.

Chromium levels also reported in this study to exceed the permissible limit for fish and fish products, though, in biological usable form plays an important role in glucose metabolism, is also a notable hazardous metal. The adequate intake (AI) of Cr is 35 µg/day and 25 µg/day for young men and women, and could be less for younger persons (Trumbo et al., 2001). That means, the level reported in this study could be hazardous to the consumers of the fish when it accumulates in the body overtime. Also, risk assessment indices calculated in this study was high for this metal across the different age classification (DIM, HQ, HRI, and TTM). Findings of this study corroborates with the report (Hothem et al., 2007).

Cu, Pb, Cd, which were also higher than the permissible levels for fish and fish products in the current study aligns with (Abubakar et al., 2015) did not agree with previous work on the heavy metals of fish species. Though Cu is essential for good health but an intake above the permissible level can result in liver and kidney damage (Ahmad et al., 2022). The mean concentrations of copper reported in this study was lower than that reported in previous studies (Frías-Espericueta et al., 2014; Kareem et al., 2016). Also, the HRI of Cu and Cd were >1 making the consumption of the fish sampled hazardous to the consumers.

The Total aflatoxins recorded in the gills of sampled fish from both coldrooms reported to have exceeded the permissible limits (4 ppb) could be due to its direct contact with the water and thus, the major organ of accumulation of aflatoxins. It is the first barrier of defense and the first organ to be exposed to suspended particles in the water column (Ahmed et al., 2015). Though, recorded to be lower in the muscle of the fish than the permissible limit, it is too close to the maximum aflatoxin level for human food (4ppb) according to the Commission of the European Communities (2001). Aflatoxins are immunosuppressive, mutagenic, teratogenic, and carcinogenic, if found in large quantities in foods, it can cause several health hazards to consumers (Gholamour Azizi & Rouhi, 2013).

CONCLUSION

The heavy metal loads (Mn, Cd, Cu, Cr, and Ni) were respectively above the permissible limits set by FAO, WHO and EU legislation for fish and fish products. Thereby posing a risk to the final consumer of the fish species as revealed by the risk indices of DIM, HQ, HRI, and TTM, and this calls for serious public health concern. Total aflatoxin levels in the fish muscle sampled did not pose any threat to consumers as it was below the permissible limit. The study recommends that government should provide screening centres at the various entry points to ensure proper monitoring and screening of imported frozen fish before entry into the country.

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Assessment of DNA Barcoding of wild Cichlid (*Tilapia guineensis*) from some water bodies in South-West, Nigeria

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ABSTRACT
One of the basic requirements for proper and correct organism (Fish) identification is ability to classify scientifically using DNA barcoding which is used to assign a biological specimen of species. The aim of this study was to establish an inclusive barcoding reference database of Tilapia guineensis and assess the applicability of using the cytochrome c oxidase subunit I (COI) gene for the identification of fish at the species level. DNA was extracted from fresh fish tissue (caudal fin) using phenol-chloroform isoamyl alcohol method, DNA quantification with spectrophotometer and barcode gene region 5′ region of the mitochondrial cytochrome oxidase subunit 1 (CO1) was amplified using Fish F1 primer. Amplified products were visualized on 1% agarose gel electrophoresis, purified and sequenced unidirectionally. The sequence obtained were edited, viewed, aligned and compared with sequence from Gene bank. Phylogenetic tree constructed among the populations and with other sequences from Gene bank. Three major clusters were generated with 99% of similarity in identification among the populations; 94%-96% of similarity was also observed with other species from other countries. This study shows high degree of confidence and proper taxonomic identification by DNA barcoding of these species in the studied water bodies. This suggests pure strains of Tilapia guineensis for broodstocks can be obtained from wild which will require proper conservation and management for breeding program.

INTRODUCTION
Mitochondrial DNA molecular technique (mtDNA) is widely used for species identification. One of the most popular genes in mitochondrial DNA used for identification is Cytochrome c oxidase I (COI) gene. This CO1 gene proved to reveal species identity, phylogenetic pattern and genetic diversity of aquatic species (Tan *et al*., 2019). The success of CO1 gene in identifying species cannot be separated from gene amplification in polymerase chain reaction (PCR) technique.

Cichlid, generally known as Tilapia has become an important well-established sea food commodity. *Tilapia guineensis* is one of the most important estuaries fish in world aquaculture. It is widely cultured in many tropical and subtropical countries of the world; this is because of its rapid growth rates, high tolerance to adverse environmental conditions, efficient feed conversion, ease of spawning, resistance to diseases and good consumer acceptance make it a suitable fish for culture (Shelton, 2002). Despite these attributes, little is known about DNA sequences major source of new information for advance understanding of identification, evolutionary and genetic relationships (Hajibabaei,2007) for increasing fish production in aquaculture purposes. It is therefore necessary that the gene sequence, CO1, may serve as milestone for the identification of related species at molecular level. This study was done to assess DNA barcoding of wild cichlid (*Tilapia guineensis*) from some water bodies in south-west, Nigeria.

MATERIALS AND METHODS

Sampling Location

The sampling locations were Ondo Lagoon, Oyan dam and Lagos Lagoon with coordinates N $5^0$55′05″ and E$4^0$59^{0}′ 2″; N$7^0$15′30 ′ and E$3^0$15′20′ and N$6^0$29′ 24″ and E$3^0$23′58″ respectively

Collection of Samples

The species were collected from the sampling locations with cast net by the help of fishermen; taxonomic classification was done with the aid of the field guide to Nigerian freshwater fish and freshwater fishes of Nigeria (Idodo-Umeh,2003. Their caudal fin clips were cut and stored in Eppendorf tubes filled with 95% ethanol for molecular analysis.

DNA extraction and quantification

DNA was extracted from the caudal fin tissues (0.5g- 0.75g) of 6 samples; 2 samples per location using phenol-chloroform isoamyl alcohol method according to Sambrook and Russell (2001). The DNA quantification was checked with nano-spec photometer (Shimadzu corporation Japan, MODEL UV-1800,2000 series) by measuring absorbance at 260nm and 280nm.

Agarose gel

Agarose gel of 0.8% (Plate 9) and 1% weight per volume (w/v) were used to run both the DNA and PCR

PCR and Sequencing

Amplification was carried out in 20 µl final volume containing 10 µl of 2 x mastermix (Syd Labs, Inc., USA), 8 µl of nuclease free water and 0.5 µl (about 10pmol) each of forward and reverse primer (FISH1), and 1 µl (about 50 ng) of the genomic DNA in a thermocycler (Biorad, USA). The cycling conditions for the PCR reactions were: 94^0Cfor 5 minutes initial denaturation, 30 cycles of 94^0C for 60 s, 59.5^0C for 60 s and 72^0C for 120 s with final extension at 72^0C for 8 minutes. The PCR products of COI and IGF-1 genes were sequenced unidirectionally using Big Dye Terminator cycle sequencing kit (Applied Biosystems, Foster City, CA, USA) at at Inqaba West Africa Laboratory in South Africa using the forward primers.

Statistical Analysis

Sequence analysis was carried out using Bio Edit (version 7.0) and Mega 5.0.

RESULTS

DNA Purity and Quantification

The concentration and purity values are shown in Table 1, with mean Concentration value range between 672.04ng/l to 3889.40ng/l and Purity value range of 1.75 to 2.02 with the use of nano-Spectrophotometer. The dendrogram showed 4 major clusters (figure 1) namely: Cluster 1 consists (Lagos broodstock TG 1); Cluster 2 (Ondo broodstock TG 11, Lagos TG broodstock); Cluster 3 (Oyan dam broodstock TG 15, Ondo broodstock TG 10) and cluster 4 (Oyan dam broodstock TG 09) were 99% in similarity of identification. Figure 2, showed dendrogram of the fish population with other countries from Asia (Philippines) and Africa (Mauritania) samples where 3 major clusters were generated. The level of similarity in Figure 2 showed that 94% and 96% of *Tilapia guineensis* (broodstocks) with other *Tilapia guineensis* from other countries Asia (Philippines) and Africa (Mauritania) respectively.

Table 1: DNA Quantification

Locations	Concentration	Purity
Lagos Lagoon broodstock 1	830.87	1.76
Lagos Lagoon broodstock 2	2036.24	1.93
Ondo Lagoon broodstock 1	1319.40	1.75
Ondo Lagoon broodstock 2	3889.40	1.91
Oyan dam broodstock1	672.04	1.89
Oyan dam broodstock 2	1260.09	2.02

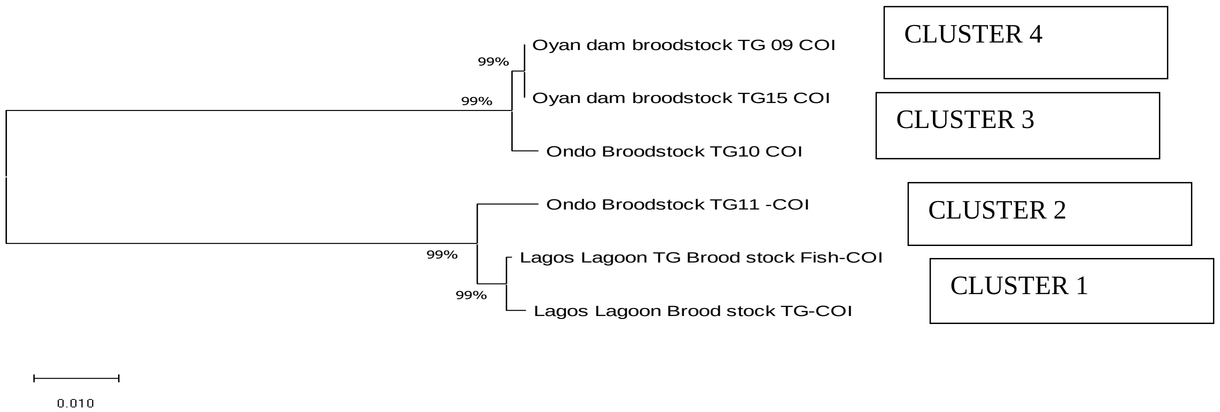

Figure 1: Dendrogram showing the identification relationship among *Tilapia guineensis* broodstocks populations in the study locations.

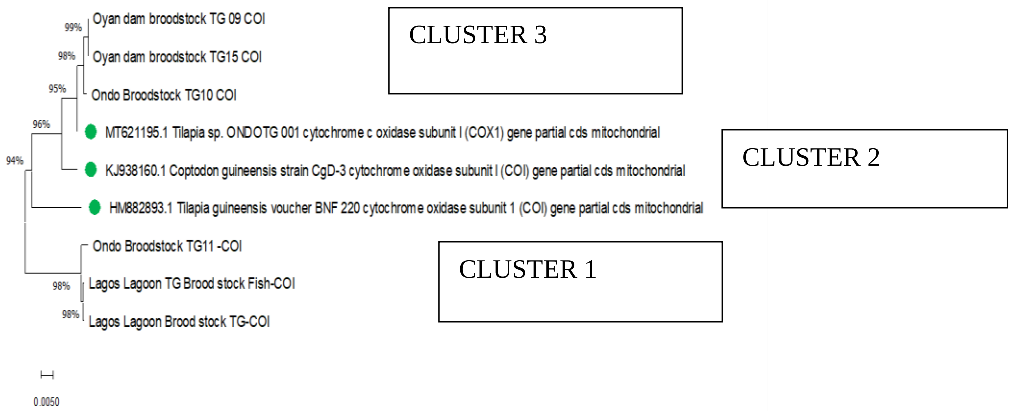

Figure 2: Dendrogram showing the identification relationship between *Tilapia guineensis* broodstocks populations from the study locations and other countries from Asia (Philippines) and Africa (Mauritania) samples.

DISCUSSION

In the present study, the results of DNA concentration showed good quantity and quality with high purity. This is in agreement with Usman *et al.* (2021) who observed large amounts of high quality and quantity of DNA on comparison of different incubation times in the DNA quantification using modified phenol- chloroform isoamlyl alcohol protocol for extraction. CO1 sequence results of the samples (broodstocks) also showed the identification of broodstocks from different locations with low intraspecies variation and high divergence from closely allied taxa which suggests high genetic similarity among the species from different locations. This is in accordance with Popoola *et al.* (2022) who observed distinct cluster on phylogenetic tree on DNA barcoding of Tilapia species from North-east part of Nigeria. The level of similarity with other countries is similar to the finding of Hurbert *et al*. (2008) and Mohanty *et al*. (2015) in which CO1gene was used in distinguishing North-American freshwater fishes and cultivable with high similarity in their study of cultivable cryptic species into different clustered group respectively.

CONCLUSION

There is little or no information about the genetic diversity among the populations of these cichlid fish. This study contributes to the use of DNA barcoding as a high degree of confidence and proper taxonomic identification of these species in the studied water bodies. This study suggests pure strains of *Tilapia guineensis* for broodstocks can be obtained from wild which will require proper conservation and management for breeding program.

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Proximate Analysis Of Three Fish Species

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ABSTRACT
Fish are an excellent source of high quality protein, vitamin and other nutrients vital to good health, including iron, calcium, potassium and iodine. Moisture, protein, ash and fat content in the bodies of 3 fish species *Dasyatis margarita* (Gunther 1870), *Claries gariepinus* (Burchel 1822) and *Pseudotolithus senegalensis* (Valenciennes 1833), were investigated. Moisture content ranges from 72.1 to 75.4%, with *P. Senegalensis* having the highest moisture content followed by *C. gariepinus*. The protein content ranges from 23.7 to 20.2%. The maximum and minimum protein values were reported for *D. margarita* and *P. senegalensis* respectively. Average concentration for ash content was found to be highest in *D. margarita* (2.6%) and lowest in *C. gariepinus* (2.1%). All the fish species were found to be low in fat content with *D. margarita* having the least (0.2%). This information can be harnessed for maximum benefits of the consumer, however, further research on the lipid compositions of this fishes are needed for the maximum benefits.
Key words: Proximate analysis, Fish, Moisture, Protein, Ash and Fat.

INTRODUCTION
Fish plays a vital role in feeding the world’s population and contributes significantly to the dietary protein intake of millions of the populace. Fish are an excellent source of high quality protein, vitamin and other nutrients vital to good health, including iron, calcium, potassium and iodine. (Suganthi *et.al.*, 2015). The fats found in fish contain unsaturated fatty acids which do not pose a threat to the heart as they help reduce blood triglycerides.

Some authors have reported on proximate composition of fishes (Ndome *et.al*, 2010, Akpambang 2015, Suganthi *et.al.*, 2015). However, such information is scanty and there is still need to further analysize the proximate composition of some other fishes. The present study is aimed at evaluating the proximate composition of three common fish species which are readily available and consumed in Nigeria.

MATERIALS AND METHODS

Sample Collections and Preparation.

Three fish samples comprising of *Dasyatis margarita*, *Clarias griepinus* and *Pseudotolithus senegalensis* were used for this study. All the samples were identified using standard taxanomical texts (FOA 2012). They were purchased from Makoko fish market, Yaba Lagos Nigeria. Cleaning, eviscerating, filleting and deboning were carried out on the samples. All the samples were lyophilized (SB4 Freeze drying machines, UK), milled (Sharp blender, model HR 2815), Wrapped with aluminium foil and packaged into labeled plastic containers. The samples were stored at a temperature of -20^{0}C prior to analysis.

Chemical Analysis

The moisture contents of the fishes were determined before freeze-drying the samples. This was done using a forced air oven at 105^{0}C first for five hours and repeated for 30 minutes interval until a constant weight was obtained. The loss in weight was calculated as the moisture content A.O.A.C. (2005). Fat was quantified using procedure of A.O.A.C.(2005) with hexane (68.5^0 -69.1^{0}C) as solvent. The protein content of content of each fish was assayed by the micro-kjeldahl method as reported by Kirk and Sawyer (1991). The gram of nitrogen obtained was multiplied by the factor of 6.25 to obtain the protein content of each fish sample. The ash content of respective sample was determined by dry-ashing the samples at 55^{0}C for 24h. Data obtained for protein, ash and fat were correlated for moisture and presented on weight basis.

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Statistical Analysis:

Analysis of samples were carried out in triplicates. One way analysis of variance (ANOVA) was used for data analysis, post hoc analysis was done by the use of Duncan's multiple range test and means were separated at $P<0.01$ using the statistical package for social scientist computer software packages (IBM 2012).

RESULTS AND DISCUSSION.

The biochemical composition of fish varies from one species to another, depending on the number of factors, including feeding, breeding, fishing season and migration (Suganthi *et.,al* 2015). The moisture contents of the fish samples are represented in figure 1. The fish species have moisture contents within the range of 72.1 to 75.4%. The moisture content in decreasing order *P. senegalensis, C. gariepinus to D. margarita*. The values obtained in this study are within the values reported by Boran and Karacam (2011) for horse mackerel (65-75%) from black sea of turkey.

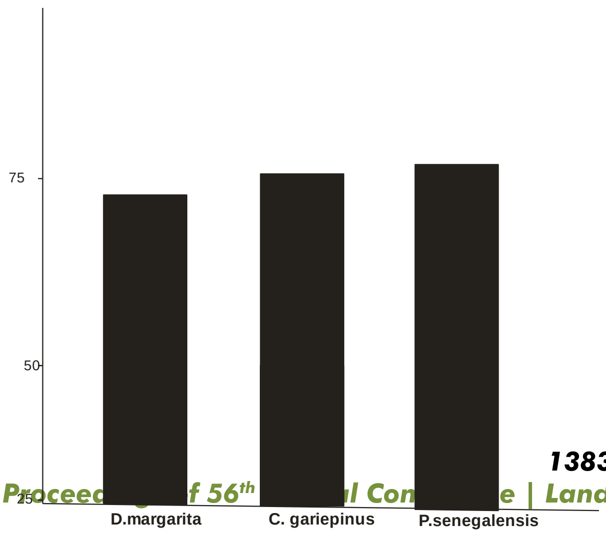

Figure 1: Moisture content of fish samples

The protein content of the fishes in his study are within the range of 23.7 to 20.2%. This present result is in agreement with the values reported by (Suganthi *et.al*, 2015) for *Stolephorus commersonii* (23.67%) from Muthet mangrove. *D. margarita* is of high nutritional value with (23.7%) protein than *C. gariepinus* and *P. senegalensis*. This could be as a result of its preference for shrimps diet which is equally of very high nutrient value (Oyebanji 1991).

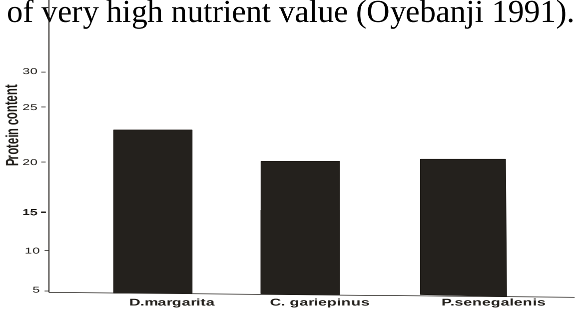

Figure 2: Protein content of fish samples

Ash content varied from (2.6%) in *D. margarita* to (2.1%) in *C. gariepinus*. The value obtained for ash content in the present study are similar to the observation made by Oyebanji (1991) who recorded 2.7% ash content for *D. margarita*.

The observed range of ash content indicated that the studied species are a good source of minerals such as calcium, potassium, zinc, iron and magnesium (Ndome *et. al*, 2010).

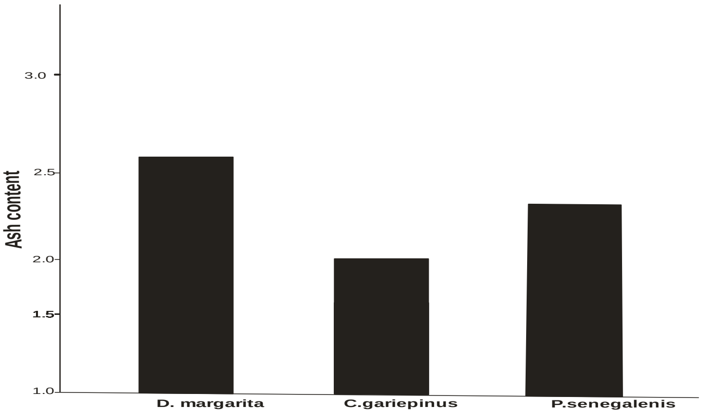

Figure 3: Ash contents of fish samples

All fish types were found to be low in fat content with *D.magarita* having the lowest value (0.2%).

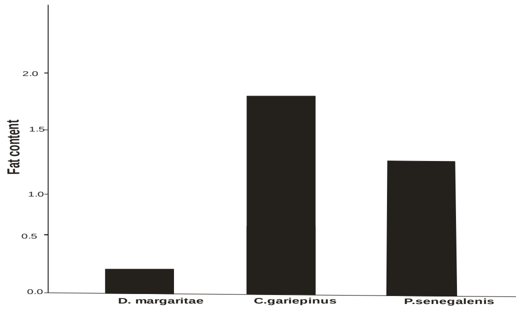

Figure 4. Fat contents of fish samples

CONCLUSION:

The study has revealed variation in nutritional benefits derived from the fish species studied. This information can be harnessed for maximum benefits of the consumer, however, further research on the lipid compositions of this fishes are needed for the maximum benefits.

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Development, nutritional and acceptability analysis of catfish roe butter

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ABSTRACT
Up to 80% wastes and by-products are generated from fish processing activities; by-products can be used to develop functional products of positive health, economic and environmental impacts. Catfish roe butter (CRB) was developed. The nutritional composition and acceptability of CRB were determined. The protein, lipid, moisture and ash contents of the developed product were (22.65±0.15), (28.10±0.10), (46.87 ±0.01) and (1.22±0.00) % respectively. The calcium, iron, magnesium, phosphorus and zinc contents of CRB were (11.38±0.06), (0.75±0.00), (18.80±0.13), (396.35±0.20) and (2.14±0.02)mg/100g respectively. The oil of the CRB was found to be `rich in polyunsaturated fatty acids while the cholesterol level was (326.33±1.70) mg/100g. The developed CRB is nutritious and well-accepted by the sensory panellists. The developed CRB constitute healthy food that can be used as source of nutrient especially in children diet.

Keywords: Catfish roe, catfish roe butter, Nutritional Composition, Sensory Attributes

INTRODUCTION
There is a strong demand for fish products due to increasing consumer awareness of the nutritional benefits of fish (Diouf, 2019) and a source of high quality food (Abeywardena and Patten, 2011; Dyck *et al.,* 2011) recommended as a means of preventing cardiovascular and other diseases (Alasalvar *et al*. 2011; Cruz Casallas *et al.,* 2012).
Nigeria is the largest producer of catfish in Africa with over 300 Metric Tonnes annually (FDF, 2017). Fish roe (eggs) and other by-products could be derived from catfish processing and value addition activities such as filleting, drying, smoking and canning. To maximise profits, wealth creation and to save the environment, it is very important to make use of fisheries wastes and under-utilized fisheries resources as by-products for functional products that are nutritious and of health benefits.

MATERIALS AND METHODS
Fresh catfish roe was collected from Kado fish market, Abuja, transported in icebox to the laboratory of Fisheries and Aquaculture Department, Prince Abubakar Audu University, Anyigba. The roe was rinsed with clean water, soaked in 3% brine solution for 5 minutes and steamed for 2 minutes. The steamed catfish roe was then added to the mixture of coconut milk and groundnut oil. Blended banana paste was added to serve as a binder and sweetener, turmeric and lime were added

for colour and preservation. The mixture was thoroughly mixed to give a uniform paste, which was packaged in a plastic tube and refrigerated for nutritional and sensory analyses.

Proximate analysis

Protein was determined in triplicate by Kjeldahl method using Foss Kjeltex^{TM} 2100. There were three steps involved: Digestion, distillation and titration as described by (ISO, 2005).

Lipid content was determined in triplicate by Bligh and Dyer (1959) with slight modification of breaking up the lipids with N-hexane.

Moisture content was determined by difference in weight of the homogenised samples before and after drying for 24hr in an electronic oven at a temperature of 104± 2 °C (AOAC, 2004).

Mineral determination

Wet digestion of the sample was done and the minerals were identified and quantified with the use of Atomic Absorption Spectroscopy (AAS) and as described by AOAC, 2004 and EPA 7000A and B, (1990).

Fatty acids composition

The fatty acid composition of the total lipids extract was determined by gas chromatography of fatty acid methyl esters (FAMEs) based on AOAC 996.06 (2001).

Cholesterol determination

The total cholesterol was determined by AOAC, (2010), official method 994.10, cholesterol in foods.

Sensory analysis

Twenty (20) trained panellists who are familiar with and usually include fish products in their diet made judgement on the appearance, taste, flavour and overall acceptability of the dried catfish roe products. The sensory analysis was done using the following points: Like extremely (9), Like very much (8), Like moderately (7), Like slightly (6), Neither Like nor Dislike (5), Dislike slightly (4), Dislike moderately (3), Dislike very much (2), Dislike extremely (1). The sensory panellists were selected by the procedure described by Meilgaard *et al.* (2006) with slight modification.

Data analysis

The data generated were analyzed using Microsoft Office Excel 2013.

RESULTS AND DISCUSSION

The results of the proximate analysis of fresh catfish roe (CR) and catfish roe butter (CRB) are presented in Table 1. It was observed that CR and CRB are rich in protein. Wirth *et al*, 2011 reported similar chemical and biochemical composition of sturgeon roe. Protein rich food is necessary for growth and repair of body cells, increase protein intake improves gain in muscle mass and strength in adults (Wirth *et al.*, 2020).

Table 1: Proximate composition (%) of catfish roe and catfish roe butter

Proximate composition	Catfish roe	Catfish roe butter
Protein	27.77±0.01	22.65±0.15
Lipid	1.59±0.01	28.10±0.10

Moisture	62.77±0.06	46.87±0.01
Ash	2.56±0.01	1.22±0.00

The mineral composition of CRB is presented in Table 2. CRB is a good source of minerals such as calcium, iron, magnesium, phosphorus and zinc. Food rich in minerals are needed for body growth and development. They are needed to live long and stay healthy and their deficiency can lead to disorders and disease symptoms (Gharibzahedi and Jafari, 2017). According to Food and Agriculture Organization (FAO) food balance data, it has been calculated that about 20% of the world's population could be at risk of zinc deficiency (FAO, 2001). CRB is rich in phosphorus which is needed in bones and teeth formation. It helps the body to utilize carbohydrate and fats and make protein for growth (NIH, 2021).

Table 2: Mineral composition (mg/100g) of catfish roe butter

Mineral	Catfish roe butter
Calcium	11.38±0.06
Iron	0.75±0.00
Magnesium	18.80±0.13
Phosphorus	396.35±0.2
Zinc	2.14±0.02

Catfish roe butter is rich in fatty acids composition, the ratios of omega-6 to omega-3 and polyunsaturated fatty acids to saturated fatty acids fall within the acceptable limits by WHO, 2005. The ratio of omega-6 to omega-3 in modern diets is approximately 15:1, whereas ratios of 2:1 to 4:1 have been associated with reduced mortality from cardiovascular disease, suppressed inflammation in patients with rheumatoid arthritis, and decreased risk of breast cancer (HMSO, 2001). There is increasing interest in dietary cholesterol due to the connection of plasma cholesterol levels with the risk of cardiovascular diseases. (Zhong, *et al*. 2019; Zhuang, *et al*., 2021). It has been reported that between 20-25% of the cholesterol in the body comes from the food of animal origin such as egg, Zhuang, *et al*., 2021). It is therefore necessary to know the concentration of cholesterol in our diet to prevent cardiovascular diseases. The body needs about 300 mg dietary cholesterol per day and an individual should eat moderately dietary cholesterol for proper body metabolism (Clayton, *et. al*., 2017).

Ta**ble 3: Fatty acids composition (%) and cholesterol composition mg/100g of catfish roe butter**

Fatty acids composition (%)	Mean ±SD
Total fatty acids composition	98.66±0.68
Saturated fatty acids (SFA)	41.25±0.25
Monounsaturated fatty acids (MUFA)	35.45±0.18
Polyunsaturated fatty acids (PUFA)	21.86±0.35
PUFA/SFA	**0.53**
Eicosapentaenoic acid (EPA)	0.11±0.01
Docosahexaenoic acid (DHA)	0.59±0.02
n-3 (Omega -3 fatty acids	4.96±0.22
n-6 (omega -6 fatty acids	17.10±0.22

n-3:n-6	**1: 3.45**
Cholesterol (mg/100g)	389.92±5.66

SD = Standard Deviation
Values in red are some indices for measurement of oil quality; WHO, 2005 (n-3/n-6≤5:1 PUFA/SFA>0.4

The results of the sensorial analysis, demonstrating preference criteria like appearance, taste, flavor and overall acceptability for the CRB is presented in Table 4. The results showed high level of acceptability of CRB.

Table 4: Sensory attributes of catfish roe butter

Attributes	Catfish roe butter
Appearance	7.60±1.10
Taste	7.40±1.39
Flavour	7.35±1.23
Overall acceptability	7.60±1.10

CONCLUSION

It was observed that appreciable percentage of roe (eggs) and other by-products could be derived from catfish processing and value addition activities such as filleting, drying, smoking and canning. The study indicated that catfish roe butter was well accepted by the panellists and is a good source of protein, minerals and lipids which are excellent in polyunsaturated fatty acids. The PUFA: SFA and n-3: n-6 ratios of the catfish roe butter is within the recommended value by WHO, thus constituting healthy food.

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Sub-Theme D:
Biosafety issues in agriculture, Smart agriculture and climate changes, Agriculture engineering and mechanization strategies

Proper material selection in agricultural machines fabrication as a remedy to reducing food contamination – a review

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ABSTRACT
The food processing industry is one of the fast growing sub-sectors in Nigeria. The industry which is mainly composed of medium and small scale firms depends on the locally developed food processing equipment. Due to lack of proper material selection practices employed by the equipment manufacturers, the materials normally selected for most designs are not the most appropriate ones hence compromising the quality of the equipment produced. This has not only led to poor quality food products due to contamination but could also turn hazardous to the health of the product consumers. This study involved the assessment of the current materials selection and fabrication procedures used by the food processing equipment manufacturers with a view of devising best practices that can be used to improve the quality of the food products processed using the locally fabricated machines. Results of the study show that fabricators experience business biasness, and their desire to minimize cost, compromise the material selection procedures. In addition to failing to choose the best material for a given application, most machine fabricators are commonly fabricating machines with inadequate surface finish and improper weldments. This hinders the machine's ability to meet food hygiene standards. This study also accessed agricultural mechanization in Nigeria, and the choice of material used for fabricating most food processing machines. The benefits of agricultural mechanization and proper material selection were identified. The level and problems of Agricultural mechanization in Nigeria were also highlighted.

Keywords: Material selection, proper, Agriculture, Mechanization, food contamination, product contact surface, design

INTRODUCTION
Food security and sustainable agriculture have become burning in the national discuss at all levels of government as plans are being made for a changing global climate and increasing global population. (Asoegwu, 2007). Hence the need for engineers who would enhance, through technology, the production, processing, storage and distribution of food across our country, Nigeria, so as to maximize production and minimize losses of food. Researchers over the years have proven that agricultural mechanization which involves a balanced application of the trio of technologies (biochemical Technology, Physical/Engineering Technology and socio-economic Technology) is the key (Ani and Onwualu, 2002). In any product development the major aim is to achieve equipment

that fulfils its engineering function. However, specifically for food processing equipment, the requirements for hygiene is often conflicted. Whilst, in seeking any acceptable compromise, it is imperative that food safety is never compromised to this kind of risk. The criteria for hygiene design of food contact surface should ensure that the surface are smooth, impervious, free of cracks and crevices, non-porous, non-absorbent, non-contaminating, non-reactive, corrosion resistant, durable and maintenance free, non-toxic and cleanable (). If the surface is coated with metal alloy, ceramics, plastic, or rubber in any way, the final surface must meet the previous criteria but also the 3A hygiene standards. The 3A standards require that such coating maintain corrosion resistance, and be free from surface delamination, pitting, flaking, chipping, blistering, and distortion under conditions of intended use. Similarly, if any modifications or process is used in fabrication it should be done using appropriate materials and in a manner that ensures the final surface meets the hygiene design criteria.

There is no doubt that the application of farm power to appropriate tools, implements and machines – “farm mechanization”- is an essential agricultural input in sub-saharan Africa (SSA) with the potential to transform the lives and economies of millions of rural families. Farm mechanization can facilitate increased output of higher value products while eliminating the drudgery associated with human muscle-powered agricultural production. (faborode, 2005). Improved livelihoods for smallholder farmers means increased access to input supply chains and integration in modern food systems, resulting in improved incomes, numerous and renewed business opportunities, further value addition and overall improved livelihoods for smallholder families. Moreover, agricultural mechanization in its broadest sense can contribute significantly to the sustainable development of food systems globally, as it has the potential to render post-harvest, processing and marketing activities and functions more efficient, effective and environmentally friendly. (FAO, 2007). Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the material for a given application begins with properties and costs of candidate materials. Material selection is often benefited by the use of material index or performance index relevant to the desired material properties. A thermal blanket must have a poor thermal conductivity in order to minimize heat transfer for a given temperature difference. It is essential that a designer should have thorough knowledge of the properties of the material and their behavior under working conditions. Some of the important characteristics of materials are: strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, welded or hardened, machinability and electrical conductivity. Systematic selection for application requiring multiple criteria is more complex. (Aamir, 2020). The objective of this study was therefore to evaluate the advantages of proper material selection in agricultural machine fabrication.

Problems of Agricultural Mechanization and Material Selection for Food Processing

The agricultural sector notwithstanding many decades of neglect remains the highest employer of labour in Nigeria. The sector employs about 70% of the labour force in the country. Despite this landmarks made by Agriculture in Nigeria, the sector has been unable to meet the food demands of its populace. (Odigbo, 2000). There are many constraints to successful farm mechanization in Nigeria and they include: land tenure system, poverty of farmers, inadequate spare parts, seasonality of operation, and lack of extension agents. Other noticeable problems of Agricultural mechanization are: lack of experts to handle machines, peasant farmers have small fragment of farm land, most of the machines cannot adapt to our local soil type, land tenure system in Nigeria, economic factors, government policies, inadequate operators. (IFPRI, 2010.)

The problem of material selection and that of agricultural mechanization are interwoven with little disparity in line with food processing. In other to reduce health challenges like cancer and other life threatening ailment caused by the introduction of heavy metals into our food during processing, material selection for food processing dos and don’ts cannot be overemphasized. There are many constraints to successful material selection in Nigeria and they include: finishing: production deficiencies and cooling methods. (Shanian, 2006). stainless steel has been recommended for use in design and fabrication of food processing machines, presence of defects and holes in the plates are cracks and corrosion initiation sites. The mechanical and physical properties of a selected material are not known to the designer. (Rao, 2008).

Benefits of Agricultural Mechanization and material selection for food processing
Advent of agricultural mechanization in the first republic in Nigeria was targeted on getting the youth involved in agriculture. Then the federal government discovered that to meet up with the demand of the international market and also to tackle the menace of rising unemployment with the increasing number of graduates, it had to make agriculture very attractive to the youths of that time by importing some good number machines to help ease human-powered efforts. (sahel, 2017). Agricultural mechanization have scored some good points in Nigeria and its benefits includes: increased productivity, reduced health hazard due to manual or over labour drudgery, it saves time, encourages large scale farming, promotes specialization of available manpower, create employment for youths, hand-on knowledge of the material selected, encourages multiple cropping which was not possible under traditional farming and supplements human-powered effort in several folds for heavy jobs. Proper material selection will give assurance on its overall stability, sustainability and mechanical attributes. Most importantly, good selection of materials for design and fabrication of engineering machines meant for food processing industry, promotes good health because of the following: right material selection (stainless is preferred to mild steel even if that mild steel was coated with the best of insulators), it promotes HQC, saves cost of maintenance, promotes durability, and encourages exportation.

Level of Agricultural Mechanization and Material Selection in Nigeria
Nigeria mechanization rate of 0,27HPH is well below the FAO recommended rate of 1.5HPH. For every 10,000 hectares of arable land, farmers have access to 6 tractors (sahel, 2017). Agricultural mechanization includes three main power sources: human, animal and mechanical. Based on these sources, the technological levels of mechanization have been broadly classified as (i) hand-tool technology, (ii) animal draught technology, and (iii) mechanical power technology. Though, the mechanical power technology has suffered a setback in Nigeria, because of government policy and leadership negligence. (Adamade and Jackson, 2014)
The level of food processing in Nigeria is below par. The food processing landscape in Nigeria is underdeveloped and largely dependent on imported processed foods, due to the minimal investment in technology and knowledge for local processing. Nigeria is the world sixth largest producer of cocoa beans producing 248,000 tons in 2016; however, only about 74,400 tons (representing 30% of total production) of cocoa beans are processed locally. The remainders are processed in countries such as France and the Netherlands, from which Nigeria imports end products like chocolate and cocoa powder. Similarly, a lack of processing facilities has resulted in Nigeria, the largest producer of tomatoes in sub-saharan Africa becoming the largest importer of tomato paste in the region. (Rao, 2008)

Solution to Problems of Agricultural Mechanization and Material Selection
Solution to agricultural mechanization in Nigeria includes: provision of credit facilities which should accessible to farmers, availability of farm machines, farmers should form a cooperative society, loans are easily accessed as a team, the land tenure system should be reviewed to make land available for farming, simple and less expensive machines should be developed and made accessible to farmers, there should trained engineering personnel to maintain either imported or located built machines, machines should be produced using the best health friendly material in the case of food processing machines, fertilizers and manure should be used to increase production of crops in the available

lands, crop rotation should be practiced by farmers, there should be a synergy between the agriculture extension workers and the rural farmers, the land use decree of 1978 should be fully implemented to minimize the problems of land tenure and provide adequate education to farmers. (sahel et al., 2017). For a good material to be achieved, engineers must know the following: material environmental impact, durability, material tensile and compressive strength, hardness, manufacturing process, cooling methods, elasticity and toughness. Engineers and fabricators must take decision of the material to be used before hand, material to be purchased must be inspected, and there is need for market survey and preparedness as choice materials are often expensive. Fabricators must have the knowledge of the material they want to purchase. During design and fabrication, there is need for production carefulness so as to avoid producing machines with many point defect and imperfections.

CONCLUSION AND RECOMMENDATIONS

Engineers are in the forefront of providing solutions to the problems of food insecurity in Nigeria through mechanization by introduction of machineries to boost agricultural and food production. Agricultural mechanization in Nigeria is undergoing a process of transition to a market economy, with substantial changes in the social, legal, structural, productive and supply set-ups. Since the world is shifting emphasis from traditional ways of farming to a wider spectrum, the government is expected to formulate policies that will encourage mechanization of agriculture. Government should create a body that will certify food processing machines okay for use in food processing industries; this will help control the rising number of cancer patients and other terminal health challenges on the increase due to heavy metal found in our processed foods in Nigeria. Majority of newly discover illness are traceable to wrong material selection used for food processing purposes, since there are little or no government regulation on material selection, the choice of material for fabrication of food processing machines are mostly decided by the local fabricators, leaving much to be desired about processed foods in Nigeria. It is important that a product designer should know the mechanical and physical properties of the material to be used for fabrication.

This study suggests that proper awareness, education and training should be encouraged, and government should enact laws that will prohibit the use of substandard metals and coatings for fabrication of mainly food processing machines. This will go a long to giving agricultural mechanization its footing in Nigeria, and at the same time encourage exportation.

Table 1: AISI, DIN and EN designations of stainless steels for food equipment

AISI	DIN/EN	Typical analyses					
		C%	Cr%	Ni%	Mo%	Ti%	N%

304 L DIN (EN 1.4307 X2CrNi 18-9)	<0.0-3	18	9	-	-	
316 L DIN (EN 1.4435 X2CrNiMo 18-14-3)	<0.03	18	14	3	-	-
410 DIN 1.4006 (EN X12Cr 13)	<0.1-2	13	<0.75	-	-	
409 DIN 1.4512 (EN X2CrTi 12)	<0.03	11.5	-	-	<0.65	-
329 DIN 1.4460 (EN X3CrNiMo N27 -5-2)	<0.0 <0.25 0	27	5.5	1.7	-	

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Corrosion behavior of steels in Nigeria food processing industry

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ABSTRACT
The presence of heavy metal in processed foods is on the increase in recent years due to corrosion and improper material selection for food processing purposes. This research was conducted to determine the corrosivity of mild steel (uncoated), galvanized steel and stainless steel (304L) using the weight loss method over a period of 98 days with measurements made at 14 days interval in ground melon (locally called Egusi), cassava pulp, mashed palm fruit, tomato pulp and black-eyed bean pulp respectively. The result obtained show that the average corrosion rate of 304 stainless steel, galvanized steel and mild steel are in ground melon (1.98×10^{-3}, 1.81×10^{-2}, 2.65×10^{-2}) mpy; in cassava pulp (3.68×10^{-3}, 7.09×10^{-1}, 5.64×10^{-1}) mpy; in mashed palm fruit ($4,75 \times 10^{-3}$, 2.38×10^{-1}, 2.83×10^{-3}) mpy; in bean pulp (3.07×10^{-3}, 9.25×10^{-1}, 1.16) mpy, and in tomato pulp (5.46×10^{-2}, 6.99×10^{-1}, 7.83×10^{-2}) mpy respectively. Comparing these corrosion rate data with respect to that of stainless steel in each condition shows that in ground melon galvanized steel and mild steel had corrosion rates 91.41 and 13.38 times that of stainless steel; in cassava pulp 183.68 and 148.11 times that of stainless steel: in mashed palm pulp 50.08 and 58.58 times that of stainless steel: and in bean pulp 301.3 and 377.85 times: and in tomato pulp 128.2 and 14.34 times respectively. Presentation of the average corrosion rate and average specific weight loss of mild steel and galvanized steel, relative to that of stainless steel enables an easier assessment of the corrosion resistance of these substitute steels, which is envisaged will be of immense benefit to the local food and quality regulatory agencies and food processing equipment fabricators. These results suggest a dependable data when the questions on material selection for food processing are asked.
Keywords: Corrosion, Steel, Behavior, Food Processing, Nigeria

INTRODUCTION
Corrosion which is the deterioration of a material of construction or its properties due to reaction with the environment is a problem in a lot of industries and is even a greater challenge in the food processing and pharmaceutical industries, where in addition to the loss of production time for maintenance and risk of equipment failure, there exists the additional risk of product contamination by corrosion products which may result in food poisoning. As a consequence food processing machines are fabricated with stainless steel irrespective of the cost. Despite wide recommendation of stainless steel, other materials like tinned copper had

been employed successfully. (Fontana, 1987). There has been an increase in the local fabrication of food processing equipment using materials that are not stainless steel, thus reducing cost. The fabricators uses different varieties of metallic materials ranging from mild steel, galvanized steel to different grade of stainless steel.

The chemical composition of the metals and the food processing environment is important as it will to a large extent determine the possible corrosion reactions rate. Food stuff contain a lot of chemicals (mainly organic), which when allowed to stand can become substrates for microbial attack which may lead to production of chemical products which are aggressive to metallic materials. The organic acid present in food is the major corrosion agents. The effects of these chemicals can be influenced by the environmental conditions of processing such as temperature, flow rate, viscosity of the food media, and presence of stresses in the system. Exact analysis of the constituents of food stuff is a challenge due to their very complex composition (purseglove, 1981).

Most foods are acidic (McSwane et al, 2003; Bailey and Bailey, 2005; Reger et al. 2009) and since steels are active in acidic medium are susceptible to corrosion in food processing media. The processing of cassava tubers yields hydrogen cyanide with most varieties reoorted to contain 15-400mg cyanide/kg fresh weight and a few varieties containing up to 1300-2000mg cyanide/kg (fresh weight) in the tubers and 1000-2000mg/kg cyanogenic glucosides on a dry matter basis in the cassava leaves (Padmaja and Steinkraus, 1995). In cassava products, cyanide exist in three forms; as linamarin and lotaustralin, as cyanohydrins, and as the free hydrocyanic acid (HCN) (Tewe, 1991). HCN is a weak acid and is normally not corrosive, however, it exhibits a corrosive effect under two special conditions; in solution with water HCN cause transcrystalline stress cracking of carbon steels under stress even at room temperature and when in dilute solution in water containing H_2SO_4, HCN severely corrode steel above 40℃ and stainless steels above 80℃ (Maxwell, 2004). The corrosion effect of cassava fluid on steel has been the focus of a lot of research efforts (Jekayinfa et al, 2009; Loto and Atanda, 1998; Oluwadare and Agbaje, 2007; Oluwole et al., 2009). Tomato is acidic, with most varieties having pH below 4.5 as it contains a cocktail of organic acids. The major organic acids present are citric acid and to a lesser extent, malic acid, in addition to several carboxylic acids, sugar acids and alicyclic acids. (Yilmaz, 2001). The ripe oil palm fruit (Elaeis guineensis) contain in the oily mesocarp, fat of composition 70-75% of dry matter, which consists of 39-52% oleic acid, 32-45% palmitic acid, 5-11% linoleic acid, 2-16% stearic acid and 1-6% myristic acid (Asiedu, 1972). Same was derived for Egusi seed and Black-eyed beans respectively.

MATERIALS AND METHODS

Forty-five samples of each type of steel was cut from metal sheets to dimensions of (25 x 50 x 1.15)mm for stainless steel, (24.5 x 50 x 0.9)mm for galvanized steel, and (24 x 50 x 1)mm for mild steel, with a 3mm diameter hole drilled towards one longitudinal end for suspension in the test media. The sharp edges were smoothened with a hand file. Next the specimens were cleaned in acetone, dried, weighed with an analytical balance to an accuracy of 1/10th of a milligram to obtain the initial weights of the test coupons, labeled and polypropylene strings attached for suspension in the media.

The five indigenous food environments employed in this study; ground melon locally called egusi (Citrullus lanatus), cassava pulp (Manihot esculenta), mashed palm fruit (Elaeis guineensis), tomato pulp (Lycopersicon esculentum), and black-eyed bean pulp (Vigna unguiculata unguiculata), were prepared as follows. The melon, cassava pulp, the mashed palm fruit, black-eyed bean, and the tomato pulp environment was prepared by grinding 1500g of all the selected food except for black-eyed bean which was prepared by soaking 1500g of the beans in cold water for about 10 minutes.

This study of three trial environment were poured into plastic containers and labeled. Nine specimen of each of the three types of steels used in the study were immersed in these four different food media respectively. Every 14 days, samples of each type of steel is removed from each food media, observed, washed in running water with a rubber bung to remove corrosion products, washed in ethanol, and then acetone, dried and weighed to determine the final weight from which the total weight loss, specific weight loss (weight loss per unit exposed area) and consequently the corrosion rate is computed.

RESULTS AND DISCUSSIONS

The results obtained show that the average corrosion rates of 304 stainless steel, galvanized steel and mild steel are in ground melon melon (1.98×10^{-3}, 1.81×10^{-2}, 2.65×10^{-2}) mpy; in cassava pulp (3.68×10^{-3}, 7.09×10^{-1}, 5.64×10^{-1}) mpy; in mashed palm fruit ($4{,}75 \times 10^{-3}$, 2.38×10^{-1}, 2.83×10^{-3}) mpy; in bean pulp (3.07×10^{-3}, 9.25×10^{-1}, 1.16) mpy, and in tomato pulp (5.46×10^{-2}, 6.99×10^{-1}, 7.83×10^{-2}) mpy respectively. Normalizing these corrosion rate results (Table 1) with respect to that of stainless steel in the respective media enable easy comparison of how fast the substitute materials corrode in each media relative to 304L stainless steel. Manipulation of corrosion data in this way, is believed to be suited to the equipment designer, and shows that in ground melon galvanized steel and mild steel had corrosion rate 91.41 and 13.38 times that of stainless steel; in cassava pulp 183.68 and 148.11 times that of stainless steel: in mashed palm pulp 50.08 and 58.58 times that of stainless steel: and in bean pulp 301.3 and 377.85 times: and in tomato pulp 128.2 and 14.34 times respectively. Since the corrosion in food processing environment is usually more concerned with product contamination than with equipment failure, the presentation of corrosion data, in a form that gives the knowledge of quantity of metal likely to be passed into the product as a result of corrosion is preferable. In this regard the corrosion data has been presented in mpy (mils per year) and also in terms of (specific metal loss per unit time in $mg/cm^2/day$). To indicate the quantity of metal getting into the food per unit area of the metal exposed per unit time. This is beneficial with knowledge of the chemical composition of the metal alloy and assuming a uniform corrosion of all the constituent elements in the alloy, the elemental contamination in the food can be evaluated. The specific metal los into the food media was recorded to be for stainless steel, galvanized steel and mild steel as; (1.15×10^{-3}, 6.84×10^{-2}, 1.19×10^{-2}) $mg/cm^2/day$ in ground melon; in cassava pulp (1.05×10^{-3}, 1.57×10^{-2}, 1.96×10^{-1}) $mg/cm^2/day$; in mashed palm fruit (1.53×10^{-3}, 5.67×10^{-2}, 7.74×10^{-2}) $mg/cm^2/day$; in bean pulp (1.34×10^{-3}, 2.4×10^{-1}, 1.89×10^{-2}) $mg/cm^2/day$, and in tomato pulp ($1.82 \times 10^{*3}$, 1.3×10^{-1}, 1.91×10^{-2}) $mg/cm^2/day$ respectively. Normalizing these data, with respect to that of stainless steel shows that in metal ingress per cm^2 per day of galvanized steel and mild steel in ground melon is 59.5 and 10.31 times that of stainless steel; in cassava pulp 149.68 and 186.59 times; in mashed palm fruit 37.02 and 50.57 times; in bean pulp 179,29 and 14.07 times, and in tomato pulp 71.17 and 10.49 times respectively,

CONCLUSION

It is observed that the corrosion rate was generally lower for the two oily food processing environments; ground melon (Citrullus lanatus), and mashed palm fruit (Elaeis guineensis), than for the water based ones for the three steels studied. This is believed to be gradual penetration of oily corrosion products which inhibited further corrosive activity. As expected, the corrosion rates for stainless steel was negligible in all the food processing environments while black-eyed bean pulp environment was most corrosive to mild steel and galvanized steel. The highest corrosion activity was observed in the galvanized steel while in the bean pulp, then in cassava pulp and tomato pulp environments within the initial 28 days, at that time all zinc coating on the galvanized steel had been washed off.

The results obtained show that (i) mild steel possess better corrosion resistance than galvanized steel in Nigeria food processing environments except in the bean pulp environment. (ii) the use of galvanized steel for food processing purposes is not beneficial (from the corrosion and economic point of view), (iii) the experiment show that the ground melon environment was the least corrosive of the food processing environments, (iv) while the black-eyed bean pulp environment was the most aggressive of all the other steel under study except stainless steel. (v) tomato pulp environment is the most aggressive of them all.

Table 1: Normalizing average spec. wt. loss and average corrosion rates based on 304 stainless steel, showing how many times mild steel and galvanized steel corrode in different media compared to stainless steel

	NORMALIZED SPECIFIC WEIGHT LOSS			NORMALIZED CORROSION RATES		
ENVIRONMENTS	**304 L**	**MILD STEEL**	**GALVANIZED STEEL**	**304 L**	**GLAVANIZED STEEL**	**MILD STEEL**
GROUND MELON	**1.00**	**10.31**	**59.5**	**1.00**	**91.41**	**13.38**
CASSAVA PULP	**1.00**	**186.59**	**149.68**	**1.00**	**183.68**	**148.11**
MASHED PALM-FRUIT	**1.00**	**50.57**	**37.02**	**1.00**	**50.08**	**58.58**
BEAN PUPLP	**1.00**	**14.07**	**179.29**	**1.00**	**301.3**	**377.85**
TOMATO PULP	**1.00**	**10.49**	**71.17**	**1.00**	**128.02**	**14.34**

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Cathodic protection system as a panacea to corrosion – a review

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ABSTRACT

The need to control the erosion in part or whole of metals, which is responsible for food contamination, failure of machines, and cost of maintenance birthed sacrificial anode cathodic protection (SACP) system. The purpose of cathodic protection (CP) is to reduce the potential difference between anodes and cathodes to a small value. This study explores empirically the role of cathodic protection in corrosion control. A metal is said to be cathodically protection at a stipulated value of (-850mV) and overprotected at a value above (-1150mV). The problems of cathodic protection using magnesium as sacrificial anodes were identified. Coating technology as a means of metal protection by cathodic involvement was discussed. The benefits of cathodic protection were highlighted. The process of installation of a working CP system and the type of soil that will guarantee a good CP system were discussed also. The level of CP system application in Nigeria was discussed also and its relevance analysed.

Key Words; Cathodic Protection, Electrochemical, Corrosion, Coating, Soil Analysis

INTRODUCTION

The invention and first application of cathodic protection is attributed to Davy in 1824 in a project financed by the British Navy which succeeded in preventing the corrosion of copper sheathing of the wooden hulls of the British Naval ships (Peabody, 2001). About 1820 the Navy Board was anxious to find the reason why copper sometimes got fouled, whilst iron was dissolving, and at other times the copper was dissolving rather too quickly which birthed cathodic protection. Kuhn made considerable research in connection with the corrosion of cast iron pipes in the soil. Those studies indicated that galvanic currents of great magnitude circulated around a corroding pipe and that these currents discharge at the points of corrosion and collected on other areas. He stated that ordinary corrosion could be prevented by reversing these currents. In 1933, Kuhn postulated that the potential needed to step down corrosion rate is probably in the range of -850mV (Kuhn, 2006). The methods used in the control of corrosion are coating, cathodic protection, material selection, environmental modification, and design practices. Control of underground corrosion is primarily achieved by two methods: coating and cathodic protection. An effective external coating can provide corrosion protection to over 99% of the exposed pipe surface (Kuhn, 2006).

Corrosion cell resulting from contact of dissimilar metals leads to a cell in which one is active (negative) with respect to the other. In cathodic protection, the above stated is taken advantage of by purposely establishing a dissimilar metal cells normally existing on pipelines. This is accomplished by connecting a very active metal to the pipeline. (Umezurike, 2008). This metal will corrode and in so doing will discharge current to the pipeline. Cathodic protection does not eliminate corrosion; rather it displaces corrosion from the structure being protected to sacrificial anodes. (Jones, 2011). The sacrificial anode must have a potential that is more negative than that of the protected structure. When the sacrificial anode is connected to the structure, it is polarized anodically and the two will reach the same potential, provided the resistance of the electrolyte is sufficiently low. Thus an essential requirement is that the anode will polarize the steel to a potential where it will not corrode at all, or corrode at an acceptable rate, for an acceptable period of time at an acceptable cost. For maximum efficiency of protection, self-corrosion of the anodes should be eliminated by alloying. (Ovri, 2011). To a large extent, the economic impact of corrosion control to any society can be clearly seen in terms of its effect on the GNP. Nevertheless, some relatively high-resistivity soils may be very corrosive, e.g. acidic peaty soils and anaerobic soils containing sulphate reducing bacteria. Corrosion can also occur in fairly high resistivity soils if there is a considerable variation in the resistivity at different points along the route of the pipeline to be protected, causing concentration-cell effects.

The resistivity of the soil can vary greatly with its water content and with the electrolyte dissolved in the water. Thus the soil resistivity at a given location may vary with the season of the year and the rainfall. For a proper design of a cathodic protection system, current output can be predicted from soil resistivity data. It is estimated that between 3-5% loss is recorded on the Gross National Products of industrialized countries. These have been attributed to corrosion damages. (Peabody, 2001).

Problems to be avoided in the use of cathodic protection

The major problem relating to cathodic protection systems is the production of hydrogen ions. A side effect of improperly applied cathodic protection is the production of atomic hydrogen, leading to its absorption in the protected metal and subsequent hydrogen embrittlement of welds and materials. Excessive negative potentials can cause accelerated corrosion of lead and aluminium structures because of the alkaline environments created at the cathode. These alkaline conditions may also be detrimental to certain coating systems and may cause loss of adhesion of the coating (Davies *et al*., 2012). Hydrogen evolution at the cathode surface may be on high strength level, this will result to hydrogen embrittlement of the steel, with subsequent loss of strength. On some high strength steels, this may lead to catastrophic failure. It may also cause disbondment of coatings; the coating would then act as an insulating shield to the cathodic currents. Any secondary structure residing in the same electrolyte may receive and discharge the cathodic protection direct current by acting as an alternative low-resistance path (interaction). Other problems resulting to failure of installed CP systems are: soil type, cathodic shielding, the handling of some important components of a CP system, high Ph environment, and expensiveness of packaged anodes. (Mattson, 1996).

Soil condition

Soils are complex and their aggressiveness is determined by factors such as moisture content, oxygen content, dissolved salts, pH and organic matter content. The major constituents that accelerate corrosion are chlorides, sulphates and the acidity (pH) of the soil. Calcium and magnesium tend to form insoluble oxide and bicarbonate precipitates in basic environments, which can create a protective layer over the metal surface and reduce the corrosion. In contrast, the chloride ion tends to break down the otherwise protective surface deposits and can result in corrosion pitting of buried metallic structures. Bicarbonates are not typically detrimental to buried metallic structures. (Okorafor, 2001).

Coating technology as an assistance to effective CP system

Coatings are used to isolate the anode and cathode regions. Coatings also prevent diffusion of oxygen or water vapour that initiates corrosion or oxidation. Temporary coatings, such as grease or oil, provide some protection but are easily disrupted. Organic coating, such as paint, or ceramic coating, such as enamel or glass, provides better protection. However, if the coating is disrupted, a small anodic site is exposed, that exposed site undergoes rapid, localized corrosion (Ronald, 2001). Factors to be considered when selecting coating materials are nature of surface to be coated, type of contaminants (environment), compatible surface cleaning and coating application methods, number of coats to be applied, compatibility of various coats, requirements for maintenance, and economic selection of a particular system must be justified by maximum protection for money spent, both initially and during maintenance of project. (Ashworth, 1994).

CP system benefits and level of application in Nigeria

Cathodic protection is mainly used in the oil and gas industry in Nigeria. It is used to control the degree of corrosion of pipeline. Cathodic protection had not found wide application in Nigeria as it is only efficient in places with dense rainfall. (Ovri, 2011). Cathodic protection can preserve the metallic components of heavy duty machines, food processing machine among others. Corrosion can be economically and effectively mitigated using a combination of coating and cathodic protection on grain storage tanks, food processing machine, pressure tanks and pipes. (Schewedtfeger, 2010).

Solutions to problems of cathodic protection

- Steel structures corrosion can be curbed and hence environmental hazard controlled by applying systematic corrosion prevention measures.
- Instrument used for data collection or for taking readings should be cleaned after use. This is to ensure accuracy when taking subsequent readings. For example, the half-cell reference electrodes gather soils at the tip immediately it touches the earth. It is then advisable that it should be kept neat especially if it is not to be used frequently.
- Installing the anode very close to the pipe affects the performance of the CP system, the distance between the anode and pipe were supposed to be (0.5m). If this standard is not obeyed, potential readings will not conform to expected results.
- Installed sacrificial anode cathodic protection system should be allowed a minimum of 2 weeks for the system to be fully polarized without which definite values will not be achieved.
- In the cause of installation, researcher should be careful as to know if the cable(s) were still attached to the pipe and/or damage of the PVC-PVC cable. This is important when experimenting on small structures (as implies this project).
- During dry season, it is advisable to water the SACP zone for optimum values(s) to be achieved.

To achieve CP systems set objectives, more attention needed to be paid to the purchase and handling of these following materials: the polyethylene tape, the handicaps, the PVC-PVC cables, the packaged anode and gun powders.

CONCLUSION AND RECOMMENDATIONS

Cathodic protection had proven to be an effective means by which rusting in machines, metal and pipe can be controlled. Cathodic protection works by allowing a more reactive, sacrificial metal to corrode instead of the protected metal. CP application is almost predominant in oil and gas industry of Nigeria, CP can also flourish in an aggressive surrounding. With the knowledge of the amount of rainfall and soil PH of a given environment, one can draw conclusions of the performance of an installed CP system. It is therefore recommended that metal-to-soil potential measurement using -850Mv criterion is adequate to evaluate the cathodic protection performance of any structure. Installed sacrificial anode cathodic protection (SACP) system should be allowed a minimum of 2 weeks for the system to fully polarise without which definite values will not be achieved. There is need for carefulness while installing the anode so no cable attached to the anode will detach unknowingly. The government should form a policy that will promote the use of SACP both as a protection technique and also as a maintenance technique to our agro machines and tractors. This will reduce the degree of wear and tear on our locally or imported machines.

Table 1.1 Effect of chlorides, sulphates and pH on corrosion of buried steel pipelines

Concentration (ppm)	Degree of Corrosivity
Chlorides	
>5000	Severe
1,500-5000	Considerable
500 – 1,500	Corrosive
< 500	Threshold
Sulphate	
>10,000	Severe
1,500-10,000	Considerable
150 – 1,500	Positive
0 – 150	Negligible
PH	
<5.5	Severe
5.5 – 6.5	Moderate
6.5 – 7.5	Neutral
>7.5	None (Alkaline)

Table 1.2 Corrosion potential range of some elements

ANODIC or Least Noble	Corrosion Potential Range in Millivolts
Mg and Mg Alloys	-1600 to -1630
Zinc	-980 to -1030
Al alloys	-760 t0 -1000
Cadmium	-700 to -730
Mild steel	-600 to -710

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Performance evaluation and optimization of cassava grating machine: a dual-operational mode with attached magnesium anode

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ABSTRACT

Optimization of cassava grating machine which has two mode of operation was achieved. It can be either electrically or manually operated. The machine is protected against corrosion by attachment of magnesium anode across the metallic frames of the machine. Due to the kilogram of cassava pulp this machine is designed to produce per day (200kg), magnesium anode was attached to the hub of the grating machine to help reduce the corrosive effect of the cassava fluid. The anode attachment controls corrosion of the frames that come in contact with the cassava to be grated and the grated cassava pulp fluid. The cassava fluid is acidic and could become corrosion propagate medium to the hopper and metal chute being the movement channel of the cassava pulp. This process was necessary to help control the introduction of heavy metal found most times in our processed food. The quantity of anode required to protect home scale cassava grating machine was calculated and achieved.

However, this paper is interested in the electrical and manual usage of this machine with sacrificial anode attachment, high throughput and reduced cost of production. It takes care of rusting, power failure and/or erratic power supply issues, and can be used in rural areas where electric supply is either non-existent and/or unpredictable. The mechanism is such that cassava is fed to the machine through the hopper made of steel to the grating drum, which rotates at a given speed. The pulp collection chamber is inclined at an angle which permits a free fall of the pulp into the collection chamber. The efficiency when manually operated was found to be 90.84% while the efficiency of the electrically operated was 89.24%. The magnesium anode current required to protect the hopper, drum, and metal chute of the grater was 0.0096mV. The protection potential obtained was in the range of (-850mV to -1150mV) for a protected mild steel or stainless steel as NACE specified standard. This research work has the common objective of providing optimum cassava grating machine suited for garri processing with reduced contamination.

INTRODUCTION

Cassava was first introduced to Africa soil at about 1558, since then, cassava have become a major staple food providing the basic diet for over a billion of world population (Grubben, 2014). In Nigeria, cassava is mostly grown on small farms, usually a mixed-cropping system. The root starch for cassava which has been the core for its cultivation is mainly used as food 48% and as feed 34%. It is used as feedstock 18% and for biofuel and as well as biochemical (FAO, 2008).

Presently in Nigeria, the products of cassava are usually locally consumed and exportation is limited because the products do not always meet the international standards for healthy foods. There is urgent need to encourage small scale cassava machine fabrication to ensure high quality cassava products produced with the assurances of good hygienic values. FAO/GIEWS, 2001 survey conducted discovered that most of the cassava graters in the research area are usually corroding (reducing service life) due to the acidic nature of the cassava fluid and materials used for the fabrication. To ensure all cassava products is free from any taste, odor, or infected by iron content of parts (food poisoning) This study was carried out to evaluate the performance of a dual operational cassava grating machine, its output per day and the efficiency of the duality while making sure defects are not introduced into the pulp by attaching magnesium anode to the hub of the fabricated cassava grating machine for metal parts corrosion control.

Over the year, the need to transform cassava root to pulp for garri production has led to invention of several cassava grating machines available today. Hence, the trend of consistent research works that has to the progressive development of grating machines. In other to cater for the group of garri producers who have no access to electricity and/or lack the resources or know-how, Odigboh (1984) designed a manually operated cassava grating machine. Ndaliman (2006) focused on power failure problems by developing a grating machine that can be powered either electrically or manually. Adetunji (2011) designed and fabricated an improved cassava grater which modified the design of the existing cassava grater to the home use small scale sized, and to change the crude wooden drums used in cassava grating machines to lasting stainless steel and galvanized pipe.

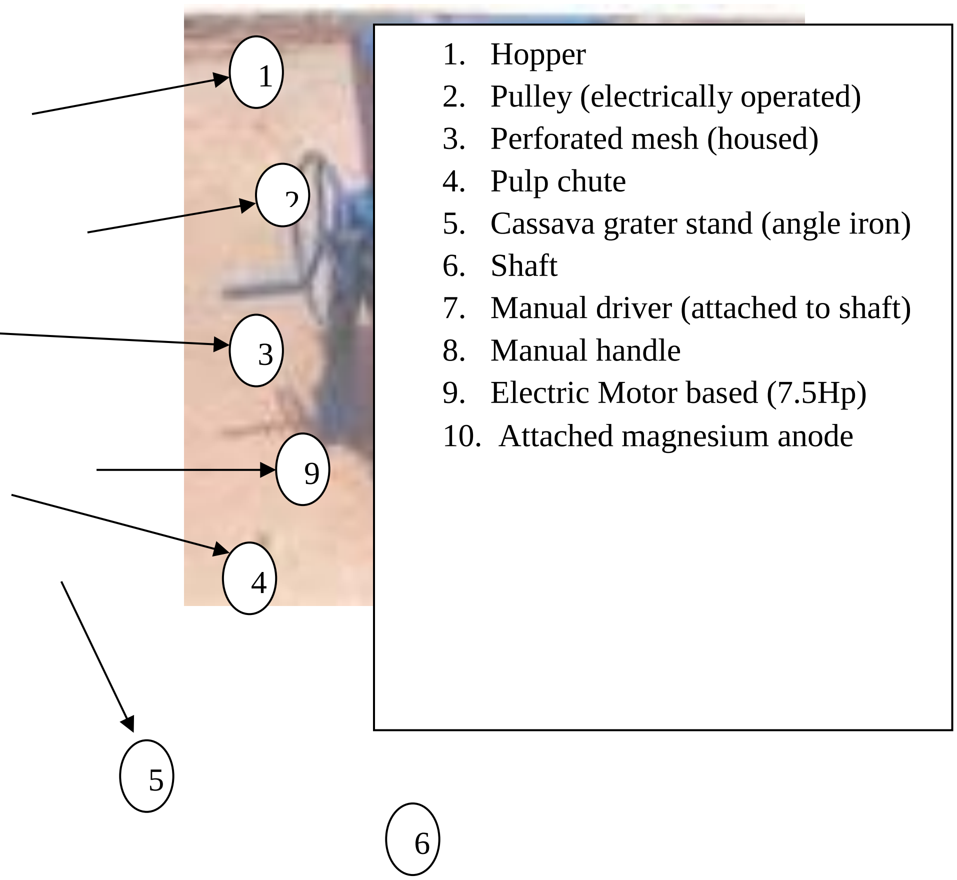
Ajao et al (2013) worked on design and fabrication*n of a home scale pedal powered cassava grater, erratic power supply, scarcity and high cost of petroleum products which necessitated the need to address the issue of cassava grating to a certain extent by developing a mechanism that will make life easier in food processing for rural dwellers and improve their economic wellbeing. Onwubali (2022) cathodic protected cassava grating machine with magnesium anode to bring to barest minimum the effect of rusting and introduction of heavy metals to grated cassava pulp. With the concept of commercialization, Oriaku et al (2015) designed and evaluated the performance of a double action cassava grating machine, while Okonkwo et al (2020) optimized a similar system with the aim of achieving a very high throughput in cassava grating and at a reduced grating time. Okoli (2021) designed and improved the performance of double barrel cassava grating machine, the consideration for the design was to achieve light weight cassava grating machine.

MATERIALS AND METHODS

Design Considerations

- The operational mode should be considered making sure its meets stipulated standard
- The machine should be easily assembled and dismantled without difficulties
- The hopper should be wide enough to be able to house 8 to 15kg cassava tubers introduced at a time
- Another problem is that cassava produces large amount of cyanogenic glycosides so in selecting materials, for fabrication, adequate care must be taken not to use materials that degrade/corrode easily.

Table 1: Materials used in the fabrication of a dual-operated cassava grating machine with attached magnesium anode for corrosion control



Description of Machine Parts

The main frame: the main frame was constructed with angle iron, this is to give the grating machine a definite shape and to stamp out wobbling. The thickness of the angle iron is 4mm.

The hopper: The hopper is the medium o by which cassava roots are introduced into the cassava grating machine. A hopper with rectangular cross section was considered. The volume of the hopper was obtained as:

$V = B (H) L (m^3)$

(1)

Where: V = Volume of the hopper, L = Length of hopper, B = Breadth of hopper, and H = height of hopper.

The mass of hopper was obtained as: $M = \rho V$ (kg)

(2)

Where: M = mass of the hopper, ρ = density of the material.

The Grating Unit: This unit consists of the shaft, perforated mesh, rolled sheet, circular discs, and rivet pins, the grating drum is cylindrical in shape. The volume of the cylinder was obtained as: $CV = 3.142.r^2 L$ (m^3) (3)

Where: CV = Volume of cylinder, r = Radius of the cylinder, L = Length of cylinder.

The force acting on the cylindrical drum was obtained as: $F_C = V.\rho.g$ [g = constant]

(4)

Where: F_C = Force exerted on the rotating drum, V = Volume of the cylinder, ρ = density of the material

Shaft Design

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is transmitted by some tangential force and the resultant torque set up within the shaft permits the power to be transferred to various machine or its elements linked up to the shaft. To be able to transfer the power to the shaft, the various members such as pulleys, bearing, and grating drum are mounted on the shaft. These members along with the force exerted upon them causes the shaft to bend. To achieve this, a solid circular shaft was considered for analysis of combined torsional and bending stresses.

For a shaft with axial load, the diameter was obtained as: $D^3 = 16/3.142T_S ((B_KB_M)^2 + (T_KT_M)^2)^{1/2}$ (5)

Force exerted on Shaft was obtained as: $W_P = M_P$

(6)

Where: M_P = Mass of the pulley, g = acceleration due to gravity, W_p = weight of the pulley

Weight of cylindrical drum was obtained as: $W_d = \rho V g$

(7)

Where: ρ = density of the matetrial, V = Volume of the material, g = acceleration due to gravity

Anode Required Protection Current: $I_A = S_A \times I_D \times F_S$

(8)

Where: I_A = Anode current, S_A = Surface area of metal, I_D = Current density, F_S = Factor of safety

Anode Designed Life Expectancy (in years): $0.058 \times W_A \times A_E \times U_{AF}/A_C$

(9)

Where: A_{EL} = Anode life expectancy, A_{LB} = Anode weight in pounds, A_{PW} = Packaged anode weight, A_E = Anode efficiency, U_{AF} = Anode Utilization factor, 0.085 = Magnesium anode constant (Stern, M. and Geary, A.L. 1957).

METHODS

Machineries and machining processes used in the fabrication processes are as follows: Drilling machine, welding machine, bending machine, milling machine, lathe machine, hand drilling/cutting disc machine, and pedal drilling machine. The anode was prepared outside the machine and the cables attached to the metallic frames.

RESULTS AND DISCUSSIONS

Performance test was carried out on the optimized cassava grater in comparison with the old wooden frame and drum cassava grating machine type, typical of the rural areas. The time taken to grate 100kg/3batches of cassava roots was compared to that of the ancient cassava grater. The time taken for each batch was obtained and data collected. The process was done using manual effort and electric powered process respectively. The result gotten was as a result of the electric motors used. It was likewise observed after a fortnight that the sacrificial anode started changing colour thereby giving up its life for the preservation of the entire machine metallic structure.
It was observed that the performance of the optimized dual-operational mode cassava grating machine improve over time. This improvement was likewise seen on the smoothness of the cassava pulp with respect to time of usage. It was observed that the perforated mesh, give smoother pulp after a given number of usages.

Table 3 gives the cost analysis used in production of one unit of the machine. The total cost of production (both manufacturing and overhead cost) of one unit is estimated to be about N66, 150:00. All material used are locally sourced.

Table 3: Cost analysis of cassava grating machine

Description	Size	Amount (Naira)
Electric Motor	(1)horse power/single phase	20,000
Bolts, rivets, electrode	Drilling bits(15pcs/13pcs/2pcs and two packets of electrodes)	8000
Cutting Discs, grinding, painting, Carrier and Flanges bearing	9”/7’ (2/1) (10kg of oil paint) (1) (8”Ø)	8150
Sacrificial Anode	7.5kg	30,000
Total		**66,150**

CONCLUSION

The optimized cassava grating machine was found to be efficient. It can grate about 200kg/hr. the magnesium anode attached to the frame of the hopper helps control the rate of corrosion from cassava fluid, fabrication defects, and other corrosion propagation channels. The machine can be powered electrically and/or manually.

This machine can be used at home-scale level for domestic purposes and is affordable since the cost of production is relatively low. Based on the anode attached to the machine and the choice of material used for fabrication of the dual-operational machine, the machine is expected to last longer than other dual-operated cassava graters. The reading gotten from the multimeter attached to the sacrificial anode used show that condition necessary for protection to take place was achieved (-860mV).

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Development of a manual multi - crop planter for peasant farmers

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ABSTRACT
A prototype manually controlled multi-crop planter was designed with changeable metering devices to reduce drudgery involved in the manual method of planting in small farms. The planter was developed and produced specifically for cowpea, maize and soybean planting to increase the productivity of planting. In this configuration, the drive shaft governs directly the seed metering function, which totally removes attachments such as pulleys, belt systems and gears, thus eliminating the complexity of conventional planters, which increase costs. Laboratory and field experiments were performed on the planter to assess the weight of seeds emitted from the planter, the percentage of damaged seed, field capacity, average seed depth in the furrow, and average seed spacing. The planter had a field efficiency of 76.3%, a field capacity of 0.39 ha/hr, and seed rates of 0.25 kg/ha, 0.18 kg/ha, and 0.21 kg/ha for cowpea, maize, and soybean, respectively. Percentage of seed damage was 3.54% (cowpea), 2.32% (maize) and 1.32% (soybean) of an average spacing of 40.8 cm and a depth of 3.98 cm. With the exception of occasional lubrication of the bearings needed to let the ground wheel to freely rotate, the single-row multi-crop planter is relatively simple to operate and requires no maintenance. The planter can be managed safely and easily. Materials for production were found locally, which means that farmers can rapidly replace worn-out sections.

Keywords: Agriculture, cowpea, maize, multi - crop planter, peasant farmers, soybean.

1. INTRODUCTION
Cereals crops, which belong to the grass family (Gramineae), are generally grown for their edible starchy seeds. Cereal crops include barley, maize (corn), millet, oats, soybean, wheat, rice, rye, etc. In Nigeria, uses of cereals range from "Akamu," "Agidi", to "Nrioka", "tuwo shinkafa" and "tuwo masara". They are used as animal feeds and fodder and in some parts of Nigeria, cereal stems are used in the construction of local huts. Cereal grains are relatively low in proteins especially the essential amino acids. They require supplements with legumes and proteins (Henry, 2005).

There are many factors responsible for low agricultural yields. These include the use of low yielding varieties, insect, diseases, weed control, inadequate cultural management practices particularly in the area of fertilization and most importantly, planting operation. Planting operation is one of the most important tasks that grains growers undertake. Planting operation of grains in Nigeria is at low level as many farmers still use bare hands or hand tools to plant their crops. However, manual method of seed planting results in low seed placement, spacing efficiencies and serious backache for the farmer, which limits the size of field that can be cultivated. Moreover, manual planting is tedious and time consuming; a hectare of land requires eight-man (Cruz and Dela, 2007). About 95% of the Nigerian farmers have small land holdings and are much below living standard.

Researchers have developed many types of implements to mechanize seed planting operation. Singh *et al.* (1985) developed a two-row ridge planter for planting winter maize and evaluated in the field over an area of 0.4 ha. Average seed distance was found to be 0.198 m, row to row spacing 0.60 m and the average ridge height was 0.25 m. The capacity of the planter was 0.10 ha/hr at a forward speed of 2.5km/h. Braide and Njidda (1989) developed a combined jab planter, which was found to be 73.4% efficient and was three times faster than manual planting with hoes and cutlass. Braide and Ahmadu (1990) developed a transplanter for some selected crops in Guinea Savannah of Nigeria, which had 0.19 ha/h field capacity and 20% field efficiency. Sule and Ohanwe (1999) developed a hand-pushed seed planter/fertilizer application for the small scale farmers. Olaoye and Bolufawi (2001) developed a tractor drawn planter for planting grains both on flat lands and on ridges. Plant spacing, uniformity and emergence rate are the most common characteristics used by producers to evaluate planter performance (Staggenborg *et al*., 2004). Ojomo and Ale (2008), investigated the performance evaluation of a row crop planter on a tilled soil.
Seed planters available in the market were imported, specifically designed to operate in large farms, expensive and not suited to local conditions. It is difficult for peasant farmers to acquire costly imported agricultural machinery and equipment (Odigboh and Ahmed, 1980; 1982; Olaoye and Bolufawi, 2001). Timeliness of operations is one of the most important factors which can only be achieved if appropriate use of agricultural machines is advocated. Presently, there is awareness in Nigeria and other developing countries that the rapid development of agriculture depends largely on the successful introduction of modern and small-scale agricultural machinery largely (Adekanye and Olaoye, 2013). Therefore, there is the need to develop a small mechanical device for small-scale planting operation. The main objective of this study was to design and fabricate a simple multi-crop hand push planter for cowpea, maize and soybean with locally available materials, evaluate the machine and determine its capacity and efficiency.

2 MATERIAL AND METHODS

2. 1 Machine Description

The manually operated multi-crop planter consists of the following parts as shown in Figure 1.
Seed hopper -The feed hopper was made of mild steel having a trapezoidal shape. The design capacity of the hopper is 200cm^3. The dimension of the hoppers is 210mm x 90mm x 200mm.
Metering disc- The metering disc or flute roller was made of 5 mm plastic (Teflon). The dimension of the flute is 10mm x 5mm with a hollow opening of 3mm.
Drive wheels - The drive wheels were made of mild steel and they are integral parts of the seed metering mechanism. The wheels have spindles that bear bolts and rotate the metering device. The surfaces of the drive wheels are fixed with 10mm long steels cut from 10mm diameter iron rod that provide necessary soil rolling resistance during forward movement of the machine.
Discharge spout - the discharged spout has an opening beneath the hollow pipe from the metering housing. The seed drops directly into the furrow.
Furrow opening device - The furrow opener (adjustable) was made of 50mm mild steel angle iron with a length of 390mm. The mild steel is slightly beveled at the lower edge (5^o) to

facilitate an easy cut through the soil. To facilitate the attachment of the furrow – opening device to its support, a pipe of 50mm and 390mm long was drilled to accommodate an 8mm diameter bolt with the nut welded on the periphery of the drilled hole. The pipe was then welded at the underside of the top portion of the furrow opening device.

Furrow covering device - was made of mild steel angle iron rectangular plate of dimension 195mm x 95mm. The rod for attachment to the support was welded to the middle of the upper edge of the plate. The covering device is inclined at an angle of 45^{o} with a spring to the direction of travel for optimum covering of the soil.

Handle - The handle consists of a hollow pipe of 9mm internal diameter, length 900mm x 420mm. A bushing of 21mm internal diameter was welded in a horizontal position to accommodate the handle. The handle can meet the heights of various operators.

Bracer: - the bracer was used to create a support between the wheel and the housing bearing the shaft.

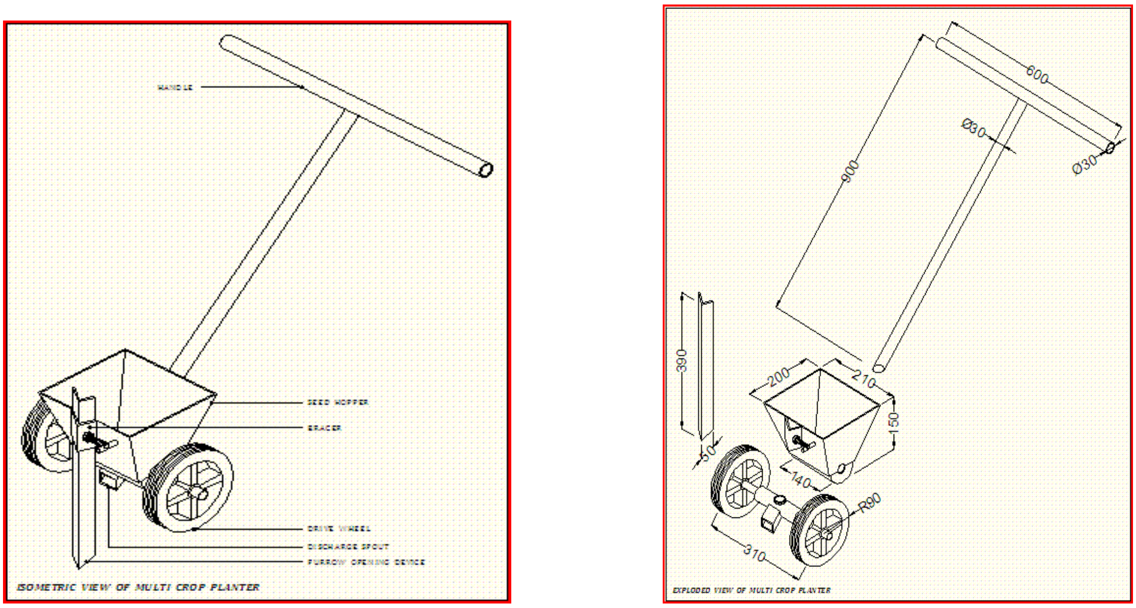

Fig. 1: Isometric and exploded views of the planter

Multi crop planter Side view of the wheel

Furrow opener and closer

Fig. 2: Component parts of the planter

2.2 Design Assumptions

The following assumptions were made in the design of the planter:

i. the linear sowing speed of the manually operated planter, 5m/s;

ii. the exposed surface of the roller, 28 cm;

iii. the bulk density of soybean, maize, and cowpea are 640.7, 716.2 and 768.8 kg/m^3, respectively; and

iv. the seed rate per hectare for cowpea (0.25kg/ha), maize (0.18kg/ha), and soybean (0.21kg/ha).

v. In the form of simulated work or pedaling at about 30 to 40 rpm, the sustainable input to any human power is regarded as 75W. The power requirement for pushing the planter is therefore assumed to be 50 watts.

2.3 Determination of physical and mechanical properties of soybean, maize, and cowpea

The range of shapes and sizes of agricultural grain crops and their physical properties like bulk density, grain length, width and thickness as determined by Ndirika and Oyeleke (2002), Shepherd and Bhardwaj, 1986, Mohammed (2002) Deshpande and Ali, 1988 and Oyeleke (2002) were adopted in designing grain cell sizes on the seed metering unit.

2.4 Design calculations

2.4.1 Determination of shaft diameter

The shaft diameter of the planter was determined using standard formula for calculating the diameter of shaft as given in Equation (1) by Gupta and Khurmi (2005):

$$d^3 = \left[\frac{16}{\pi} S_s\right] \times [(K_b M_b)^2 + (K_t M_t)^2]^{1/2} \qquad (1)$$

Where; d = diameter of the shaft, m, M_t = torsional moment, Nm, M_b = bending moment, Nm, K_b = combined shock and fatigue factor applied to bending moment, K_t = combined shock and fatigue factor applied to torsional moment, S_s = axial stress, N/m^2, S_b= bending stress, N/m^2, γ_{XY} = torsional shear stress, N/m^2. The value for the selected shaft diameter was 18.5 mm.

2.4.2 Determination of maximum draft of planter

The maximum draft on the planter is the horizontal component of push parallel to the line of motion in order to overcome the soil resistance on the planter. The maximum draft is expressed in Equation (2):

$$D_{FM} = R_S \times A_{FO} \times Acceleration\ due\ to\ gravity \qquad (2)$$

Where; D_{FM} = Maximum draft, R_S = Surface area of furrow opener in contact with soil, A_{FO} = Recommended depth of cut * thickness of furrow opener

2.4.3 Determination of seed rate requirement and the volume of hopper

The seed rate requirement, according to Gupta and Herwanto (1992) is given in Equations (3) and (4):

$$SR = \frac{1000}{W \times S_C} \times \frac{1}{1 - S} \times SW_{IR} \qquad (3)$$

$$W_{IR} = Zab \times \frac{q}{1000} \qquad (4)$$

Where; W = Working width (0.90 m as the inter row spacing, commonly used in the study area).
S_C = Circumference of the ground wheel,
S = Slip expressed in fraction,
W_{IR} = Weight of seeds fallen for one revolution or driving wheel,
Z = Number of grooves (maximum value of 4, from machine assumption),
a = number of grains per stand (2-3),
b = number of rows (1),
q = weight of 1000 grains (242.8g cowpea, 256.9g maize and 200g soybean from the assumed value of bulk density)
The volume of hopper was determined using Eq. (5):

$$V = \frac{SR}{n \times BD} \qquad (5)$$

Where; SR = seed rate per hectare, BD = bulk density, n = number of refilling per ha
The calculated values for the design were;
Volume = 163cm^3, seed rate of required: 0.25kgha^{-1} for cowpea, 0.18 and 0.21kgha^{-1} for maize and soybean respectively.

2.4.4 Determination of the force required to push the planter

The force required to push the planter was derived from Equations (6) and (7):

$$F_P = \frac{R_S cos\emptyset + W_P}{cos\theta} \qquad (6)$$

Where; F_P = Planter push force, F_R = Horizontal soil resistance force,
R_S = Soil frictional resistance force;

$$R_S = \frac{F_R tan\theta + W_P}{(\sin\emptyset - \cos\emptyset\tan\theta)} \qquad (7)$$

Ø = Angle of friction, θ = Angle between planter handle and horizontal plane,
W_P = Weight of planter.

2.4.5 Determination of planter capacity

The capacity of the planter was determined from the following expression:

$$C_{PA} = \frac{Area\ covered\ by\ planter}{10000m^2}\left(\frac{hectare}{time}\right) \qquad (8)$$

Where; C_{PA} = Capacity of planter in hectare/time,

Area covered by planter = (Inter-row spacing) x (Distance covered by planter) (m^2/time) (9)

Distance covered by planter = (Speed of planter) x (Time of planting) (m/time) (10)

3. PRINCIPLE OF OPERATION

The principle of operation of the machine is very simple and requires only one man to operate. Planting is accomplished by just pushing the device in a pre-established furrow. Since the seed hopper is directly attached to the wheel shaft, it will rotate as the wheel rotates. As the seed hopper rotates, seeds will automatically drop into the soil through the seed outlet by means of gravity. After seeding, the furrow will be covered with soil using a spike-toothed harrow.

3.1 Testing and Evaluation

3.1.1 Laboratory Test

Laboratory test was undertaken to determine and check any malfunctioning parts and defects in the design as suggested by Kepner *et al*. (1978) and Christianson and Rohrbach (1986), discovering any defect will lead to changes and improvement in the design. During the test, the number of seed discharged per outlet and number of damaged seeds were noted and recorded. The hopper was loaded with 333g of cowpea seeds, 311g of maize and 317g of soybean. The planter was suspended on a vice and turning the wheel rotates the metering device. For each investigation, the drive wheels were rotated 25 times at low speed. A stop clock was used to record the time taken to complete the revolutions. The seed discharged were weighed on a weighing balance and the procedure was repeated five times.

3.1.2 Damage Test

The test for percentage of seed damage was done with the planter held in the same position as described above; the hopper was loaded with 1kg of cowpea seeds, 1.3kg and 1.1kg of maize and soybean respectively. The wheel was rotated 20 times in turns and the time taken to complete the revolution recorded with the aid of stop clock. The seeds discharged from the spout were observed for any visible external damage.

3.1.3 Field Test

The planting of the seeds was conducted directly on a plot of 10m x 10m area (100m^2) was marked out on the field. The plot was ploughed and harrowed to get a flat bed. The planting operation was carried out to determine the distribution of seeds along rows, observe the number of seeds discharged and planted per plant stand. Furthermore, the missing points along rows, seed emergence, effective field capacity, field efficiency and percentage of germinations were determined. The effects of preparation methods of the field on which the seeds were to be planted, hopper loading capacity and the types of seeds were examined on the field with three replications.

The investigation for the field efficiency and effective field of the planter involved continuous observation and timing of each activity involved in the planting operation. Two people were involved in the determination of the field efficiency, one person operated the planter on the field while the other person observed and recorded the time for the activities. The time losses, such as turning at field ends, removal of stump and adjustments (changing metering device) were recorded. Field efficiency and field capacity of the planter was determined using Equations (11) and (12) as follows;

$$\text{Field efficiency} = \frac{Area}{Total\,time\,taken} \times 100 \qquad (11)$$

$$\text{Field capacity} = \frac{Area}{Total\,time\,taken} \qquad (12)$$

The average depth of the seeds placement was determined by running the planter at a tilted angle 45^o to the soil surface to and from over an area of 10m without the furrow covering closing the hole with a moderate setting of the furrow opener. The time taken to go across the length of the field was recorded to get the average depth; five rows were selected to take the depth using a steel rule to measure. The distances between successive seedlings within row were measured using measuring tape.

4 RESULT ANALYSIS

4.1 Laboratory and field tests

Table 1, Table 2 and Table 3 show the laboratory results obtained from the calibration of the planter for cowpea, maize and soybean. Based on the Tables, the results show that the weight of seed discharged were 4.54g, 4.44g and 4.64g respectively. The total average weight of seeds discharged during calibration was 13.62g while the mean discharge was 4.54g. This is within the range of ±7 recommended for optimum inter-furrow variation (Bamgboye and Mofolasayo, 2006). The planter effectively discharged 2 to 3 seeds per hole on the average. The planter design performance was satisfactory because the expected number of seeds were discharged from the metering device.

Table 1. Calibration Result from Laboratory Experiment of planter (Cowpea)

Weight discharged (g)	Time for 25 (sec)	Speed (rev/sec)
4.4	50	30
4.56	47	28.2
5.01	45	27
4.65	49	29.4
4.08	50	30

Table 2. Calibration result from laboratory experiment of planter (Maize)

Weight discharged (g)	Time for 25 (sec)	Speed (rev/sec)
4.8	48	28.8
3.96	50	30
4.93	47	28.2
4.37	53	31.8
4.51	49	29.4

Table 3. Calibration result from laboratory experiment of planter (Soybean)

Weight discharged (g)	Time for 25 (sec)	Speed (rev/sec)
5.01	46	27.6
4.44	53	31.8
4.63	43	25.8
4.28	40	24
4.85	41	24.6

4.2 Determination of field efficiency and field capacity

From Table 4, field efficiency was observed to be 76.3% from the average values of field efficiency trials. This shows a good and satisfactory performance as it was within the range of values obtained for planting operation by investigators (Kepner *et al*, 1978; Bamgboye and Mofolasayo, 2006). Also, the effective field capacity of the planter was 0.39ha/hr. This value agrees with that reported by Bamgboye and Mofolasayo (2006) and has a higher value than that of the manually operated seeding attachment of 0.28 ha/hr for an animal drawn cultivator developed by Kumar et al., (1986) and that of template row planter developed by Adisa and Braide (2012). This satisfactory result was due to its maneuverability, which saves time in moving and turning the planter from one point to another. Braide and Njidda (1989) developed a combined jab planter, which was found to be 73.4% efficient and was three times faster than manual planting with hoes and cutlass. Olajide and Manuwa (2014) reported effective field capacity of 0.36 ha/hr and 71% field efficiency for a row crop planter.

Table 4. Field Efficiency and Field Capacity Determination of the planter

Activity	Time for 1/10 ha (sec)	Time/ha (min)
Turning at field ends	50	8.3
Removal of stumps	120	20
Adjustments	50	8.3
Actual planting	710	118.3
Total Time	930	154.9

The design and fabrication of a manually operated multi-crop hand push planter was successfully carried out and evaluated to determine its performance. This multi-crop planter was primarily designed to cater for the need of small farm holders. The overall cost of production was minimal and would be affordable for intended end users, it is easy to maintain and required less labour to use. This planter will go a long way in making farming more attractive. All parts of the planter were fabricated from mild steel material except for the metering devices that were made from good quality plastic (Teflon).

The seed metering devices used for this work was plastic roller type with cells on its periphery. The shaft directly controls the metering device that eliminates attachment such as pulleys, belt systems, gears and thereby removing the complexities of the existing planter, which decreases the cost and increases the efficiency at a highly reduced cost. The planter was able to meter 2-3 seeds per hole with a minimum damage to the seeds. The multi-crop planter was able to plant on a flat seedbed at average field capacity of 0.39 $hahr^{-1}$ and field efficiency of 76.3% that will be quite adequate for small-scale farming. The total cost of fabrication was twenty-two thousand, five hundred naira only (about USD 61). The machine can be easily maintained without any technicality.

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SUB-THEME E:

Review on the Bio-deterioration of Agricultural Crop Produce

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ABSTRACT
Every natural or synthetic product is subject to some form of natural degradation over time under the right enabling environmental conditions. Bio-deterioration is one of the natural means of degradation. It is any undesirable or adverse change in the property of a material caused by the activities of living organisms. It involves a process of chemical and physical spoilage, caused by the continuous growth of organisms. It is sometimes complex; leading to alterations in the physicochemical and mechanical properties of the material by the action of organisms which depends on the microorganisms involved, type of substrate, and environmental conditions. The scope of bio-deterioration, products affected, causative agents, mode of action were looked into and methods available to man to tackle this natural phenomenon was also reviewed. Some of the methods were from simple cultural practices to advance techniques like nanotechnology but more work need to be done.

Keywords; Bio-deterioration, Food, Food spoilage, Microorganisms

INTRODUCTION
Bio-deterioration is a process of chemical and physical spoilage, caused by the continuous growth of identifiable organisms that can be present in foods prior to packaging and on surfaces of packaging materials (Aduroja *et al.,* 2018). This process of bio-deterioration is complex; involving alterations in the physicochemical and mechanical properties by the action of organisms, which depends on the microorganisms involved type of substrate, and environmental conditions. Food spoilage refers to various changes to food in which the food becomes less palatable or even toxic to consumers these changes may be accompanied by alterations in smell taste appearance or texture (Akinmusire, 2011).

In the case of food or agricultural products, these spoilage microorganisms can come in contact with the product from the seed before planting, through product development in the field, harvest/storage of the product and during processing and transportation (Barth *et al*., 2009).

Zabihi *et al*. (2021) further reported that physical, chemical, and biological factors work together, moving from coexistence to antagonism to cause bio-deterioration. It can apply to diverse types of materials such as food, wood, paper, leather, fuels, cosmetics, building materials and building structures and could be as a result of the metabolic activities of one of many micro-organisms or may be caused by insect, rodent or bird damage (Featherstone, 2008). The present review aims to reveal different agricultural products that are lost through the process of bio-deterioration by providing reports on the factors that influences bio-deterioration. Many fresh fruits and vegetables are sensitive to oxygen, water permeability and ethylene leading to deterioration of food quality (Gaikwad *et al*. 2018, 2020). Biotechnological techniques used to control and prevent bio-deterioration were also highlighted.

Chemical bio-deterioration

Chemical bio-deterioration is divided into two with similar results (the material becomes spoilt, damaged or unsafe) but from different causes or biochemistry.

- Biochemical assimilatory bio-deterioration – the organism uses the material as food - an energy source.
- Biochemical dissimilatory bio-deterioration – the chemical change in the food is as a result of waste products from the organisms.

Physical bio-deterioration

- Mechanical bio-deterioration – this occurs when the nature of material is physically disrupted/damaged by the growth or activities of the organisms.
- Soiling/fouling – with this kind of bio-deterioration the material or product is not necessarily unsafe, but as its appearance has been compromised, it is rendered unacceptable. The building up of biofilms on the surface of a material can affect the performance of that material.

Causes of bio-deterioration

A number of ecological factors contribute to the bio-deterioration of materials in the immediate environment apart from the inherent characteristics of organisms (Beimforde, 2011). The growth and colonization of specific biological species in specific materials is dependent on the nature and properties of the materials (mineral composition, pH, relative percentage of different minerals, salinity, moisture, and texture) and specific environmental factors such as temperature, relative humidity, light conditions, oxygen, nitrogen, level of atmospheric pollution, wind, and precipitation (Zabihi *et al*., 2021).

The bio-deterioration of different materials and substances has been extensively studied across the world.
Oyeyipo (2012) worked on the bio-deterioration of sweet potato (*Ipomoea batatas*) in Port Harcourt, Nigeria and observed that *Aspergillus niger*, *Fusarium oxysporum*, *Rhizopus stolonifer*, *Botryodiplodia theobroma* and *Penicillium* sp. were associated with deterioration of sweet potato tubers.

Hodges *et al* (2014) attributed greater post-harvest losses in cereals in sub-Saharan Africa to bio-deterioration. The organisms involved are mainly arthropods (mostly insects such as beetles and moths and sometimes mites), moulds, and vertebrates (mostly rodents such as rats and mice and sometimes birds). The study observed that bio-deterioration was enhanced by natural changes to the chemicals within grain itself and extremes of temperature and humidity. The study further observed that the weather conditions at the time of harvest are a major issue. For example, rotting grain (a special category of bio-deterioration), becomes a major problem when the harvest is close to a wet season that commences before harvesting is completed. As a result the damp cloudy weather prevents the harvested crop, or even the crop still on the plant, from drying and vulnerable to mould attacks. Postharvest losses due to bio-deterioration may start as the crop reaches physiological maturity (the crop is close to harvest). While the crop is still standing in the field, storage pests may make their first attack at this stage and when unseasonal rains dampens the crop, some mould will start to grow.

Aduroja *et al.* (2018) studied the role of three fungal species (*Neocosmospora ramosa, Aspergillus tamari* and *Aspergillus violaceofuscus*) in the bio-deterioration of onions and cucumbers in Nigeria. The study reported that *N. ramosa* was responsible for the highest rate of bio-deterioration for onions and cucumber and was resistant to both the anti-fungals (voriconazole and fluconazole) applied. The study recommended good agricultural practices that emphasize harvest and storage hygiene as effective intervention against fungal invasion of vegetables in Nigeria.

Mohammed and Kuhiyep (2020) investigated the bacteria and fungi associated with the deterioration of fresh tomatoes, (*Lycopersicum esculentum*) in Kaduna, Nigeria. The study identified the bacteria and fungi responsible for the bio-deterioration of tomato as *Escherichia coli*, *Salmonella* sp, *Staphylococcus aureus* and *A. niger Penicillium* sp, *A. flavus* respectively. The bacteria and fungi isolates were both sensitive and resistant to antibiotics and antifungal agents used.

Prevention and control of bio-deterioration

Bio-deterioration can be effectively controlled or prevented by proper understanding of the materials and the possible spoilage organisms and mechanisms (Featherstone, 2008). Bio-deterioration is as a result of either separate or combined activities of several organisms on different substrates and under different ecological conditions, therefore the prevention and control require the combined knowledge from different branches of biology, biochemistry, chemistry, physics-chemistry, etc. (Dunca *et al.*, 2014). The methods of controlling or preventing bio-deterioration range from simple cultural practices to advance application of biotechnology.

Mohammed and Kuhiyep (2020) recommended thorough washing of harvested tomatoes with clean or chlorinated water, proper handling during harvest to prevent bruises and scars or other mechanical injuries and refrigeration. Refrigeration however, is a major challenge in developing countries like Nigeria where power supply is not steady.

Sridhar *et al* (2021) studied food wastages as a result of bio-deterioration and reviewed a number of food preservation techniques including nanotechnology to increase the shelf life of fruits, vegetables, beverages and spices. The study listed heat or thermal treatment as one of the novel techniques for food preservation, used extensively in various food sectors; from bakery and dairy to fruits and vegetables (Wurlitzer *et al*.2019; Gharibi *et al*. 2020). Others are cooling and freezing used in preservation of leafy vegetables, spices and milk products to maintain all the attributes and qualities. The freezing techniques include air blast, cryogenic, direct contact and immersion freezing, while advanced techniques include high pressure freezing, ultrasound assisted freezing, electromagnetic disturbance freezing and dehydration freezing (Cheng *et al*. 2017). Ultrasound treatment involves the passing of high intensity and frequency sound waves through the food materials. This technique is versatile and has been applied in different fields ranging from medicine, healthcare to food industry (Dai and Mumper, 2010). Ozone treatment technology has been on the increase since inception due to ozone's diverse properties and quick disintegration (Sridhar *et al*., 2021). The compound quickly decomposes into oxygen molecule and produces a high oxidation potential which makes it a good antimicrobial and antiviral agent (Nakamura *et al*. 2017). This technique in combination with ultrasound has been used to maintain bacterial safety without any damage in cabbages (Mamadou *et al*. 2019). Pulse electric field technology is advancement in pre-drying treatment and requires shorter residence time for treatment of foods (Sridhar *et al*., 2021). It could be considered as a substitute to thermal drying and could enhance the food drying because of its very low temperature requirement to function (Wiktor *et al*. 2016).The use of pulse electric field has grown rapidly over the years in all food sector areas. It has been successfully applied in the preservation of Blueberries (Yu *et al*., 2017), Date palm fruit (Yeom *et al*., 2004) and Clover sprouts (Gała̧zka-Czarnecka *et al*., 2020).

Nanotechnology is the most recent concept in food preservation and has enhanced the processing and formulation of colorants, sensors, flavors, additives, preservatives and food supplements (nanoencapsulation and nanoemulsion) in both animal and plant based products (He *et al*. 2019). The introduction of nanosensors in food processing industries was as a result of its successes in other fields and nanomaterials have revealed several electrochemical and optical properties in different sauces, beverages, oils and juices (Sridhar *et al*., 2021). Different nanomaterials have been applied as sensors in different food industries - edible oils in bakery industry (Delfino *et al*., 2020), mixed fruit juices (Ye *et al*., 2020), milk (Goud *et al*., 2020), potato, onion and cabbage (Naser-Sadrabadi *et al*., 2020). In Sridhar *et al*. (2021), the emphasis was on electrothermal, freezing and pulse electric field methods because they allow both pathogen reduction and improvement of nutritional and physicochemical properties.

On the other hand, ultrasound technology and ozone treatment was recommended suitable to preserve heat sensitive foods while nanoparticles and polymer-based composites have proven to be the best solutions in food and crop preservation (Auffan *et al*. 2009; Joshi *et al*. 2019). Nanotechnology is preferred as it possess different properties like slow release action, target specific nature, precise action on active sites and high surface area (Joshi *et al*. 2019). The reason for the success of nanotechnology is due to its promising results, no pollutant release, energy efficient and less space requirements. Apart from these success factors, nanotechnology has also shown versatile applications in terms of safety, toxicity and risk assessment in areas of agriculture, food and environment (Sridhar *et al*. 2021).

CONCLUSION

Bio-deterioration is an inevitable natural phenomenon with a huge cost to man. It is capable of frustrating human development especially global food security and programmes. Bio-deterioration in different facets including scope, products affected, causative agents, mode of action, etc., have been reviewed. Because of the dimension of this natural challenge, man has devised means of minimizing its effects and has also continued to improve upon them. Some of these methods which range from simple cultural practices to advance techniques like nanotechnology were also reviewed. This review has also shown that man cannot rest on his oars now but to keep on looking for better ways of tacking this problem.

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Evaluation Of Some Nutritional And Bioactive Properties Of Artificially Ventilated Red Onion Bulbs During Storage

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ABSTRACT

This study investigated some nutritional and bioactive contents of artificially ventilated onion bulbs under seven months of storage. Moisture, protein, total carbohydrates, oil contents, energy values, total polyphenolics (TP), total carotenoids (TC) and ascorbic acids (AA) were estimated according to the standard protocols during storage period.The increasing trends in the proteins, carbohydrates and oil contents of Artificially Aerated Ventilated Stored Onions (AAVSO) were significantly different ($p< 0.05$) from control; this gave rise to a 50.08% and 5.20% energy value at the sixth month of storage. There were continuous declining trends in ascorbic acids and total carotenoids contents in the AAVSO and the control respectively leaving a 5.48% (AA) and 4.90% (TC) more retention in the AAVSO than in the control respectively. Total polyphenolic contents increased from an initial 5.10±0.02 GAE (mg/g) fresh weight to 12.08±0.00 and 9.95±1.03 GAE(mg/g) fresh weight. From the findings of this research, onion storage in an artificially ventilated structure have shown to be more desirable to curb the enormous wastage during glut and for better retention of more nutritional and bioactive compounds prior to use at home or industry. It is therefore pertinent that policy makers and non-governmental organizations should encourage and support a larger scale onion storage in an artificially ventilated structure.

Keywords: ***storage, artificial ventilation, bioactive compounds, onion***

INTRODUCTION

Onions (*Allium cepa* L.) is one of the most important and commonly used spicy vegetable through the ages not only for its culinary uses but also for its therapeutic properties. Its production remains steadily on the increase and thus making it the second most important horticultural crop after tomatoes (Prithiani *et al.*, 2022). Over 93 million metric tonnes of onion are produced globally while about 1.38 million metric tonnes are from Nigeria (FAOSTAT, 2020). Kaduna, Kano, Bauchi, Katsina, Sokoto, Borno, Nasarawa, and Gombe States account for nearly 100% (99.97) of the total production in the country (Adeoti *et al.*, 2021). Remarkably known for its aroma, taste and lachrymatory effects; it plays significant role in the industries as constituents for moth repellent, beverages, expectorants as well as condiment in biscuits (Li, et al., 2021). Studies have shown that onion bioactive molecules contribute in lowering bone reabsorption, and in prevention of degenerative diseases due to some ample amount of polyphenols and potential antioxidants. Onions have been evaluated for considerable nutritional value such as lipid, protein, reducing sugar, iron, calcium, vitamin C, phenolic contents as well as antioxidant activity (Mahmood *et al.*, 2021). Common onion varieties in Nigeria are the red Tropicana, Bombay red (brown onion), white onion among others (Oniya, *et al.*, 2021). As a seasonal crop, price tends to hit the roof during off-season thus making its availability very limited. Several attempts made to store and minimize spoilage of onion is still not very efficient and yielding especially in Africa, this can be attributed to its high moisture content (≥80%) which allows for microbial infestations (Ewekeye *et al.*, 2021). Artificial aeration of onion storage structure provides a controllable surrounding temperature and relative humidity that slows deterioration especially during long-term storage. Therefore, this study is aimed at evaluating some nutritional and bioactive compositions bimonthly of red onion stored in artificially ventilated structure with a view to minimize postharvest losses encountered in onion bulb storage.

MATERIALS AND METHODS

Collection and Sample Preparation

Red onion bulbs locally known as Yan-Gashua in Hausa language were purchased from onion farm gate in Kura, Kano state. After curing, the onions were carefully packed into an artificially ventilated onion structure and a pallet (control) for a seven-month storage period. The control used in this study is a common practice among onion handlers in Kano state. Three (3) pieces of onions representing big, medium and small in terms of weight and size were taken every two months for chemical analysis Experimental analyses were in triplicates in all cases and was initially conducted before the storage time counts as zeroth month.

Determination of Moisture Contents

Moisture content was determined according to AOAC hot-air oven method of 2006. Five grams (5g) of onion sliced was weighed into pre-weighed moisture dishes and kept in an oven set at 105°C for four hours. After a constant weight were recorded twice, the difference in weight of the moisture dishes were then weighed again post-drying and the moisture contents was calculated from the equation:

$$\% \text{ Moisture content} = \frac{(\text{weight of wet sample+ pan}) - (\text{weight of dried sample + pan}) \times 100}{(\text{Weight of wet sample + pan}) - (\text{weight of pan})}$$

Determination of Ascorbic Acid Content

Vitamin C content was determined according to titration method (AOAC, 2010). About 2.0g of macerated sample was weighed into 10ml distilled water.7.0ml of extraction solution containing 15g Metaphosphoric acid, 40ml acetic acid glacial in about 500ml distilled water was dispensed to 2.0 ml of sample aliquot. 2-3 drops of thymol blue indicator (0.1g thymol blue in 10.75ml of 0.03M NaOH diluted in 250ml water) was added to aliquot and then titrated with indophenol standard solution to rosy pink at end-point. Standard ascorbic acid solution prepared by dissolving 0.05 g in 50ml in extraction solution was then titrated in similar ways to samples.

Vitamin C (mg/100g) was then calculated as = <u>Average titer (sample -blank)</u> x 100

Average titer of standard

Determination of Total Carbohydrates

About 1g of macerated sample was placed in 25ml conical flask containing 10ml distilled water which was shake vigorously and followed by 15ml of 52% perchloric acid. After 30 minutes of votexing, mixture was filtered and about 1.0ml of filtrate was was mixed with Anthrone reagent in a test tube and absorbance taken at wavelenght 620nm using a PG-T80 Spectrophotometer. The total soluble carbohydrates was then estimated using the standard curve of glucose (Pearson, *et al*.,1976).

Determination of Oil content

Oil content was determined using soxhlet extraction method according to AOAC 2006. Three (3g) of pulverized onion sample was weighed into a thimble. The thimble was placed in the extraction unit of the soxhlet apparatus. About 230ml of petroleum ether was poured into a pre-weighed round bottom flask. The apparatus was set to boil at 80°C for 4 hours after continuous reflux of condensed solvent through the sample in the extraction thimble. The oil content was calculated using the formula: % oil content = (weight of oil extracted ÷ weight of sample) x 100%.

Determination of Protein Content

Crude Protein Content was determined as described by Kjedhal procedure in AOAC method 2006. Approximately 0.5g of pulverized sample was weighed into digestion tube, followed by addition of Kjedhal table (catalyst) then 15ml of concentrated hydrochloric acid was added. The mixture was digested at 420°C on digest stove. After digestion (clearly solution), a 40% sodium hydroxide solution was suctioned into it; then a distillation process involving the solution mixture and boric acid was made through continuous flow of distilled water in the distillation set-ups. After about 50ml of distillate was collected into the boric acid, the distillate was then titrated with 0.05M HCl using mixed indicator of bromo-cresol green and methyl red.

Protein composition was calculated as: protein (%) = $\frac{(A-B) \times 0.05 \times 1.4007 \times 6.25}{\text{Weight of sample used (0.5g)}}$

Where A = titer value of sample (ml); B = titer value of blank (ml)

Molarity of HCl used = 0.05M; 1.4007 = equivalent of atomic mass of Nitrogen

6.25 = conversion factor of nitrogen.

Determination of Total Phenolic Content

Extraction of aliquot

About 500mg of pulverized onion sample was added to 25ml of methanol-water (80:20v/v) and then sonicated for 1hour. The mixture was then centrifuged at 3000g rpm for 30minutes and extract was collected twice after being spun for the second time into Eppendorf tube and completely wrapped with aluminium foil ready for analysis.

Gallic Acid Standard Preparation

12.5mg of gallic acid crystal was weighed and dissolved in 50ml volumetric flask made up to mark methanol-water (50:50) to produce a stock solution of 250mg/L which was then used to produce solutions of 50, 100, 150 and 200mg/L.

Determination of Total Phenolic Contents

Total polyphenols contents (TPC) were determined by the Lachman *et al* (2003) method and expressed in mg gallic acid equivalent(mg/dl) of dried weight matter. 0.25ml of 500mg/L solution of each sample was added to 2.5ml Folin Ciocalteu Reagent (FCR) followed by 2.0ml of 1M sodium carbonate. Likewise, 0.25ml of each of the gallic standard solutions were used in lieu of sample to obtain calibration curve; while 0.25ml of methanol-water (50:50) was used as blank in place of sample. The reaction mixes were allowed to stand at room temperature for 15minutes in a dim light room where the absorbance were then measured spectrophotometrically at 765nm using a T80 PG-UV/Vis spectrometer. TPC was expressed as gallic acid equivalent (GAE) mg/g fresh weight (FW) of sample.

Determination of Total Carotenoids

The total carotenoids were evaluated by the spectrophotometric method described by Chan and Cavaletto (1982). About 6g of pulverized onion sample was mixed with 5.0g of celite and 15ml Methanol(70%V/V) and then filtered using Whatman No 1 filter paper. The residue was extracted up to three times using 20ml of 1:1 acetone-petroleum ether (v/v). The extract was then transferred to 500ml separating funnel where a 5ml of 10% KOH (v/v) in methanol was added and mixture allowed to stand for 90minutes. Partition achieved following the addition of 15ml petroleum ether and 20ml NaCl (20%w/v) was separated as the hypophasic layer were discarded while the epiphasic (upper) layer was washed three times with 20ml of distilled water to remove excess acetone. It was then filtered through a funnel plugged with 3.0g anhydrous sodium sulfate to remove residual water. The filtrate was made up to 100ml petroleum ether and absorbance was measured at 450nm wavelength. The total carotenoids content (µg/g) was calculated using Beer-Lambert's Law equation: A = ECL Where A = absorbance, E = Extinction coefficient of carotenoids = 1.25x104 µg/L;

C = Concentration and L = path length of cuvette (1cm)

Data Analysis

Experimental analysis was carried out in triplicate and expressed as means ± standard deviation. Data were analyzed using the t-test (SPSS 16.0 version 2007) to determine the statistical significance ($p \leq 0.05$).

RESULTS AND DISCUSSION

Nutritional Composition of stored onions

To many, onion is just a spice for food delicacies. However, its nutritional compositions cannot be over emphasized. Macromolecules such as proteins, carbohydrates, lipid (oil) contents which are precursors of total derivable energy value for any form of food substance also constitutes a profile of nutritional exigencies in onion bulbs. The onions bulbs initially collected for this research was estimated to have energy value of 80.17Kcal/100g which steadily increases during the storage periods to 92.26Kcal/100g and 84.34Kcal/100g in the experimental structure tagged AAVSO and in the control respectively (Table 1). The normal body physiology is majorly dependent on derivable energy following cascades of metabolism of protein, carbohydrates and lipid asides other micro and macronutrients. From Table 1, the observed increase in carbohydrates were quite more than it was observed in protein and oil contents. Many food substances have showed increase in protein and carbohydrates as moisture contents declines due to concentrated linkages in the amino groups and glycolytic bonds respectively (Tao and Linchun, 2008). The decreasing moisture content were due to tissue respiration of onion bulbs and was more observed with the AAVSO due to steady aeration of the storage environment.

Table 1: Some Nutritional Parameters and Energy Value of Fresh Red onion in Storage

Storage Time	**Moisture (%)**		**Protein (%)**		**Total Carbs (%)**		**Oil (%)**		**Energy Value (Kcal/100g)**	
Month	AAVSO	**Control**	AAVSO	**control**	AAVSO	**control**	AAVSO	**control**	AAVSO	**control**
0th	78.39 ±0.01^{e}	78.39 ±0.01^{e}	1.95 **±0.1^{g}**	1.95 **±0.10^{g}**	15.35 **±1.0^{h}**	15.35 **±1.00^{h}**	0.93 **±0.0^{a}**	0.9± **0.01^{a}**	80.17	80.17
2nd	71.10 ±0.0^{g}	75.02 ±0.01^{d}	2.27 **±0.1^{d}**	2.22 ±0.06^{b}	15.99 **±2.0^{d}**	15.53 ±1.50^{a}	1.13 **±0.0^{e}**	0.95±0.01^{h}	**83.21**	**79.55**
4th	**65.17 ±0.83^{f}**	**69.91** ±0.1^{a}	2.47 **±0.0^{e}**	2.35 ±0.06^{c}	16.80 **±2.0^{e}**	15.88 ±1.9^{b}	1.18 **±0.0^{c}**	0.99±0.02^{g}	**87.70**	**81.83**
6th	**61.79 ±0.01^{b}**	65.03 **±0.0^{f}**	**2.58 ±0.0^{a}**	2.47 **±0.01^{f}**	**17.34** ±0.0^{c}	16.22±0.0^{c}	**1.22±0.01^{f}**	1.02±0.01^{c}	**92.26**	**84.34**

Values are data expressed as mean ±SD of three replicates. Different superscript in the same column indicates significant difference at P<0.05. AVO= Artificially Ventilated Onions; nCVO = normal Crib Ventilated Onions.

Bioactive Composition of stored onions

The onion for this study was analysed only for ascorbic acids, total polyphenolics and total carotenoids from among many known bioactive compounds of onion bulbs. Prior to storage, the onions were analysed to have 6.21±0.05 mg/100g, 5.10±0.02GAE (mg/g) Fresh weight and 1.02±0.00 µg/g contents of Ascorbic acids, total polyphenols and total carotenoids respectively. **Fruits and vegetables with less** moisture content as a result of dehydration tends to increase some bioactive compounds (Jayeeta, *et al*.,2012, Bala *et* al., 2021). Although the composition and concentration of any bioactive compounds are dependent of certain intrinsic and extrinsic factors such as genetic and cultivars, soil and growing conditions, maturity status and postharvest storage conditions (Chaudhary, *et al.*, 2018)**. Ascorbic acids have been reported to be thermo-labile and photo-sensitive which are prone to degradation on thermal processing and storage (Jayathunge *et al.*, 2019). Table 2 above depicted the initial estimated value of ascorbic acids to be 6.21**±0.05 mg/100g prior to storage. However, there was steady decline from this initial value to 3.20±0.05 mg/100g and 2.86mg/100g in the artificially ventilated onions and the control onion respectively. This indicated that ascorbic acid declined more in the normal crib ventilated onions. This difference could be due to subsequent increase in temperature in the **control** structure than in the artificially ventilated structure during the March- July period of storage in Kano state, Nigeria. Similarly, total carotenoids were initially estimated to be 1.02±00µg/g before storage. There was continuous decline in the total carotenoids contents of the onion during the storage periods but no significant ($p>0.05$) difference in the **AAVSO** and **control** respectively. Carotenoids are less affected compared to ascorbic acid levels during storage of fruits and vegetables (Jayeeta, *et al*.,2012). The total polyphenol contents of the onions were extrapolated from the equation: $y= 0.0053x+ 0.0023$; $R^2 = 0.9986$) of gallic acid standard as shown in figure 1. It was observed that total polyphenolic content increased from the initial estimate of 5.10±0.02GAE (mg/g) fresh weight prior to storage to 12.08±0.00 GAE (mg/g) FW and 9.95±1.03GAE (mg/g) FW in **the artificially ventilated onions and the normal crib ventilated onions respectively. There was significant ($p<0.05$) in the value of total polyphenols in each periodic analysis from both onion structures. The AAVSO retained a 41.8% more of the total polyphenols than the control. This could be attributed to a less moisture content, lower temperature difference in the artificially ventilated onion structure than the normal crib onion structure.**

Table 2: Some Bioactive Parameters of Fresh Red onion in Storage

Storage Time (Months)	Ascorbic acid (mg/100g)		Total polyphenols (GAE mg/g) FW		Total carotenoids (µg/g)	
	AAVSO	control	AAVSO	control	AAVSO	control
0th	**6.21±0.05^a**	**6.21±0.05^a**	**5.10±0.02^a**	**5.10±0.02^a**	**1.02± 0.00^b**	**1.02± 0.00^b**
2nd	**5.40±0.11^c**	**5.00±0.02^g**	**5.61±0.11^b**	**5.65±0.05^d**	**0.77±0.01^e**	**0.77±0.01^e**
4th	**4.80±0.00^e**	**4.11±0.05^d**	**9.04±0.05^e**	**6.09±0.11^e**	**0.53±0.12^f**	**0.53±0.00^f**
6th	**3.20±0.05^d**	**2.86±0.11^e**	**12.08±0.00^d**	**9.95±1.03^b**	**0.07±0.05^a**	**0.069±0.05^a**

Values are data expressed as mean ±SD of three replicates. Different superscript in the same column indicates significant difference at $P<0.05$. AVO= Artificially Ventilated Onions; nCVO = normal Crib Ventilated Onions.

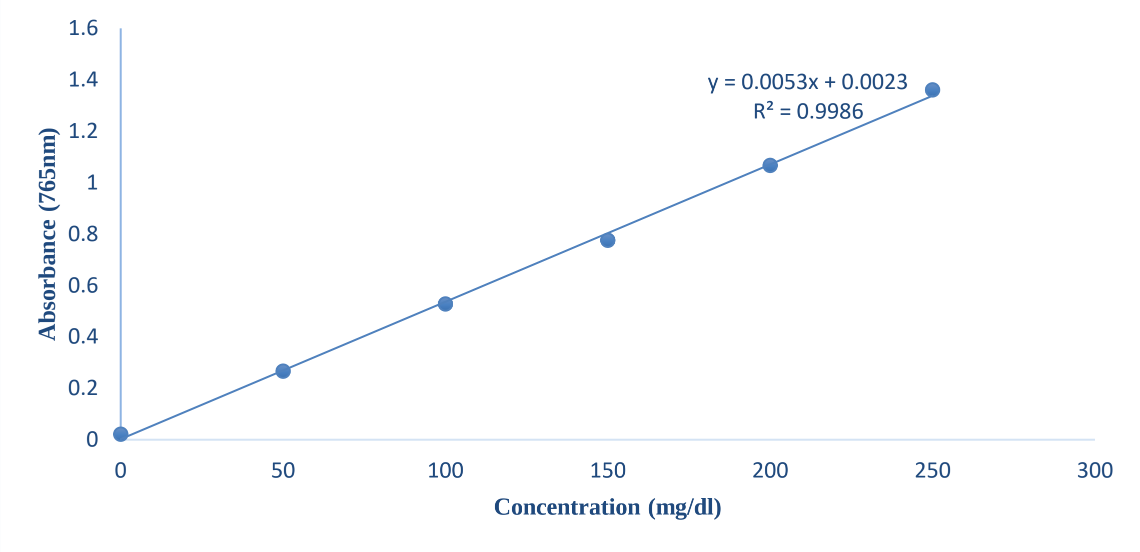

Figure 1: Plot of Gallic Acid Standard Absorbance (nm) Against Concentration (mg/dl).

CONCLUSIONS AND RECOMMENDATION

The study confirmed that there was more retention of the evaluated nutritional and bioactive compounds in the artificially ventilated onion structure than the control structure. Conclusively, onion storage in an artificially ventilated structure have shown to be more desirable to curb the enormous wastage during glut and for better retention of more nutritional and bioactive compounds prior to use at home or industry. It is therefore pertinent that policy makers and non-governmental organizations should encourage and support a larger scale onion storage in an artificially ventilated structure.

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Effects of Different Storage Methods on the Yield of living stone potato (*Plenthrantus esculentus*)

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ABSTRACT

A three year study was conducted at the National Root Crops Research Institute Umuahia Abia State to evaluate the different storage methods of living stone potato and as well affect the yield potentials. Early sprouting and rot are the major problems of living stone potato post-harvest storage. The objective was to determine the effect of different storage methods on reduction of early sprouting that will affect the yield potentials of the crop .The experiment was conducted in two stages; the first stage was the screening stage while the second stage involved field evaluation. Nine storage method used in the first stage were; bamboo raised platform , raffia palm raised platform, pit with wood shaving, pit with saw dust, pit with river sand, pit with wood ash, pit with rice husk , cemented floor, floor under shade of a tree and buried in the field,(control or farmers method), .In the second experiment pit with saw dust and cemented floor were screened out of the nine storage methods adopted due to their storage inefficiency .In 2016, seven (7) the treatments were evaluated in the field and were laid out in a randomized complete block design (RCBD) with three replicates. During the first stage of the experiment, significant differences were observed (P<0.05) in the percentage sprout count. The highest mean for both years were observed in cemented platform(17%) and pit with saw dust (16%). The highest mean percentage reduction sprout count was obtained in pit rice husk (99.5%) followed by pit with river sand (99.0%) while the least was recorded in cemented platform (83.3%) and pit with sawdust (83%).The field evaluation revealed that the tuber stored with rice husk (2 t/h) and that of river sand (2.60 t/h) gave the highest yield. The lowest yield were observed in the tubers buried in the field (0.78 t/h) and those stored in the bamboo raised platform(0.85 t/h). For effective storage of living stone potato for maximum yield, storing the tubers in pit with rice husk and pit with river sand maintained in a 60cm deep with 1mx1m is therefore recommended.

Keywords : Livingstone potato, storage methods, Postharvest, early sprouting.

INTRODUCTION

Living stone potato (*Plenthrantus esculentus*) or Rigza is one of the underutilized crop species which are very nutritious for both human and animals, the tubers are often used for substitute for potato or sweet potato. (Olojede, *et al.*, 2004). It is a dicot perennial herb and a member of a *lamiaceae* family. It is indigenous to Africa where it is grown for its nutritious edible tubers .The leaves contain a lot of vitamins and can help in digestive problems and abdominal pain.(Alleman and Coertze,1997). The tubers are mostly boiled but can be roasted baked, or fried ,it is rich in carbohydrate, vitamin A, mineral and essential amino acid. (Lukhoba *et al*,2006) . Early sprouting and rot are the major problems of living stone potato during post-harvest storage. The end of dormancy leads to initiation of sprouting which in turn means increased respiration and dry matter loss. It also determines the factor, on how long the commodity can be stored (Soctt, *et al.*, 2000). The use of different storage methods implies a strict control of environmental temperature and humidity in the storage chamber (Treche and Agbor-Egbe,1996). It is important to determine the best storage method that will control or reduce an early sprouting in living stone potato. The objective was to determine the effects of different storage methods on reduction of early sprouting and yield performance of Rizga.

MATERIALS AND METHOD

First Stage: The study was carried out in NRCRI, Umudike 2014 and 2015 cropping seasons for four months of each year. Nine different methods used were as follows; Bamboo raised platform , raffia raised platform, pit with wood shaving, pit with saw dust, pit with river sand, pit with wood ash, pit with rice husk ,buried in the field (control) cemented floor and floor under shade. Twenty 20 kg each of living stone potato and storage materials (sand, wood ash, rice husk, wood shaving and saw dust) were weighed out for the pit treatments . The weighed materials were poured inside the pit which was maintained at 60 cm deep and 1 m x 1 m size . They were mixed with the weighed tubers inside the pit. Moreover the tubers were also buried in the field and covered with soil (control or farmers method) ,the cemented floor under and floor under shade of a tree, raised platform of bamboo poles and raffia fronds also received the same quantity of weighed tubers of living stone potato . The storage sites were visited every two week interval to record Percentage sprout count and cumulative percentage.

Second stage : In 2016 two methods (pit with saw dust and cemented floor) were screened out of the nine storage methods adopted in 2014 and 2015 due to their storage inefficiency .The seven storage methods were evaluated in the field, after clearing the existing vegetation ploughed, harrowed and ridged. The field was demarcated into different plots of 2 m x 2 m with three replicates, plant spacing was 0.3 m x 1 m laid out in randomized complete block design (RCBD). All other agronomic practices were done and data were collected as at when due and subjected to analysis of variance. Means were separated with least significant difference (LSD<0.05).

RESULTS AND DISCUSSION

During the first stage of the experiment (Table1), significant differences were observed (P<0.05) in the percentage sprout count. The highest mean for the years were observed in cemented platform (17%) and pit with saw dust (16%). Consequently, one percent stand count (1%) was further observed on the following storage methods; pit with river sand, buried in the field and pit with rice husk. This also reflected in the percentage reduction sprout count. The highest mean was obtained in pit rice husk (99.5%) followed by pit with river sand (99.0) while the least was recorded in cemented platform (83.3%) and pit with sawdust (83%).

Table 2 depict the evaluation of the seven methods in the field, it was observed that the tuber stored with rice husk (2 t/h) and that of river sand gave the highest yield (2.60 t/h) . The lowest yield were observed in the tubers buried in the field (0.78 t/h) and those stored in the bamboo raised platform (0.851t/ha). The highest value obtained in storage with rice husk could be due to its bio-energy products that has a high count of cellulose and lignin according to Sheng ,(2000),this attributes contributes to the storage and yield of agricultural products. The highest yield obtained in river sand could be as a result of its cooling and drying effect on the tuber, thereby maintaining the temperature of the micro environment which result to an efficient reserve of energy from storage to the field, this confirmed the work done by Treche and Agbor-Egbe,(1996).They stated that biochemical changes during storage can affect the yield potential of tubers. The lowest value obtained in the yield of tuber stored in a raffia palm (1.05 t/h) could have resulted due to the dryness of the palm leaves after a period of time of storage which perhaps allowed the sun to penetrate towards the stored tubers which must have affected the storability and physiological components of the tubers..

CONCLUSION /RECOMMENDATION

In the first two years of the experiment there was an evidence that four storage methods (buried in the field, pit with rice husk ,pit with river sand and pit with wood ash) among the nine methods gave a better result than other storage methods, this was because their percentage sprout count reduction was above 90%. After the evaluation in the field, pit with river sand and pit with rice husk gave the highest yield in t/ha. The two methods also gave potential post-harvest storability. Therefore for effective storage of living stone potato for maximum yield, storing the tubers in pit with rice husk and pit with river sand maintained in a 60 cm deep with 1 m x 1 m is recommended.

Table1. Effects of Different Storage Methods on Percentage Sprouting of Living Stone potato

Storage methods	% Sprout count			% Reduction sprout count	
	2014	2015	me	2014	2015
Floor under shade	3.00	4.00	3.	97.0	96.0
Cemented platform	16.30	17.43	1'	83.7	82.6
Buried in the field	1.66	0	1	90.8	100
Rafia palm raised	9.30	10.7	1	90.7	89.3
Pit with river sand	1.40	1.20	1	99.0	99.0
Pit with Rice husk	1.00	0	1	99.0	100
Pit with saw dust	15.0	17.0	1	85.0	82.0
Pit with wood ash	4.66	6.80	5	95.3	93.2
Bambo raised platfo	5.00	5.81		95.0	94.2
LSD 0.05	**2.83**	**2.80**		**NS**	**NS**

Table 1.Effects of the Storage Methods on the Yield of living stone potato

Treatments	Total no. of tubers/plot (3 sampled plant)	Yield/ tonnes/ha
Buried in the field	18.05	0.780
Pit with Rice husk	21.60.	2.031
Pit with wood ash	28.45.	1.080
Pit with river sand	34.38	2.60
Pit with wood shavings	27.01	1.860
Raffia raised platform	21.22	1.050
Bamboo raised platform	19.01	0.851
LSD 0.05	**2.21**	**0.34**

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Evaluation Of Some Nutritional And Bioactive Properties Of Artificially Ventilated Red Onion Bulbs During Storage

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ABSTRACT

This study investigated some nutritional and bioactive contents of artificially ventilated onion bulbs under seven months of storage. Moisture, protein, total carbohydrates, oil contents, energy values, total polyphenolics (TP), total carotenoids (TC) and ascorbic acids (AA) were estimated according to the standard protocols during storage period.The increasing trends in the proteins, carbohydrates and oil contents of Artificially Aerated Ventilated Stored Onions (AAVSO) were significantly different ($p< 0.05$) from control; this gave rise to a 50.08% and 5.20% energy value at the sixth month of storage. There were continuous declining trends in ascorbic acids and total carotenoids contents in the AAVSO and the control respectively leaving a 5.48% (AA) and 4.90% (TC) more retention in the AAVSO than in the control respectively. Total polyphenolic contents increased from an initial 5.10±0.02 GAE (mg/g) fresh weight to 12.08±0.00 and 9.95±1.03 GAE(mg/g) fresh weight. From the findings of this research, onion storage in an artificially ventilated structure have shown to be more desirable to curb the enormous wastage during glut and for better retention of more nutritional and bioactive compounds prior to use at home or industry. It is therefore pertinent that policy makers and non-governmental organizations should encourage and support a larger scale onion storage in an artificially ventilated structure.

Keywords: ***storage, artificial ventilation, bioactive compounds, onion***

INTRODUCTION

Onions (*Allium cepa* L.) is one of the most important and commonly used spicy vegetable through the ages not only for its culinary uses but also for its therapeutic properties. Its production remains steadily on the increase and thus making it the second most important horticultural crop after tomatoes (Prithiani *et al.*, 2022). Over 93 million metric tonnes of onion are produced globally while about 1.38 million metric tonnes are from Nigeria (FAOSTAT, 2020). Kaduna, Kano, Bauchi, Katsina, Sokoto, Borno, Nasarawa, and Gombe States account for nearly 100% (99.97) of the total production in the country (Adeoti *et al.*, 2021). Remarkably known for its aroma, taste and lachrymatory effects; it plays significant role in the industries as constituents for moth repellent, beverages, expectorants as well as condiment in biscuits (Li, et al., 2021). Studies have shown that onion bioactive molecules contribute in lowering bone reabsorption, and in prevention of degenerative diseases due to some ample amount of polyphenols and potential antioxidants. Onions have been evaluated for considerable nutritional value such as lipid, protein, reducing sugar, iron, calcium, vitamin C, phenolic contents as well as antioxidant activity (Mahmood *et al.*, 2021). Common onion varieties in Nigeria are the red Tropicana, Bombay red (brown onion), white onion among others (Oniya, *et al*., 2021). As a seasonal crop, price tends to hit the roof during off-season thus making its availability very limited. Several attempts made to store and minimize spoilage of onion is still not very efficient and yielding especially in Africa, this can be attributed to its high moisture content (≥80%) which allows for microbial infestations (Ewekeye *et al.*, 2021). Artificial aeration of onion storage structure provides a controllable surrounding temperature and relative humidity that slows deterioration especially during long-term storage. Therefore, this study is aimed at evaluating some nutritional and bioactive compositions bimonthly of red onion stored in artificially ventilated structure with a view to minimize postharvest losses encountered in onion bulb storage.

MATERIALS AND METHODS

Collection and Sample Preparation

Red onion bulbs locally known as Yan-Gashua in Hausa language were purchased from onion farm gate in Kura, Kano state. After curing, the onions were carefully packed into an artificially ventilated onion structure and a pallet (control) for a seven-month storage period. The control used in this study is a common practice among onion handlers in Kano state. Three (3) pieces of onions representing big, medium and small in terms of weight and size were taken every two months for chemical analysis Experimental analyses were in triplicates in all cases and was initially conducted before the storage time counts as zeroth month.

Determination of Moisture Contents

Moisture content was determined according to AOAC hot-air oven method of 2006. Five grams (5g) of onion sliced was weighed into pre-weighed moisture dishes and kept in an oven set at 105°C for four hours. After a constant weight were recorded twice, the difference in weight of the moisture dishes were then weighed again post-drying and the moisture contents was calculated from the equation:

$$\%\text{ Moisture content} = \frac{(\text{weight of wet sample+ pan}) - (\text{weight of dried sample + pan}) \times 100}{(\text{Weight of wet sample + pan}) - (\text{weight of pan})}$$

Determination of Ascorbic Acid Content

Vitamin C content was determined according to titration method (AOAC, 2010). About 2.0g of macerated sample was weighed into 10ml distilled water.7.0ml of extraction solution containing 15g Metaphosphoric acid, 40ml acetic acid glacial in about 500ml distilled water was dispensed to 2.0 ml of sample aliquot. 2-3 drops of thymol blue indicator (0.1g thymol blue in 10.75ml of 0.03M NaOH diluted in 250ml water) was added to aliquot and then titrated with indophenol standard solution to rosy pink at end-point. Standard ascorbic acid solution prepared by dissolving 0.05 g in 50ml in extraction solution was then titrated in similar ways to samples.

Vitamin C (mg/100g) was then calculated as = Average titer (sample -blank) x 100

Average titer of standard

Determination of Total Carbohydrates

About 1g of macerated sample was placed in 25ml conical flask containing 10ml distilled water which was shake vigorously and followed by 15ml of 52% perchloric acid. After 30 minutes of votexing, mixture was filtered and about 1.0ml of filtrate was was mixed with Anthrone reagent in a test tube and absorbance taken at wavelenght 620nm using a PG-T80 Spectrophotometer. The total soluble carbohydrates was then estimated using the standard curve of glucose (Pearson, *et al*.,1976).

Determination of Oil content

Oil content was determined using soxhlet extraction method according to AOAC 2006. Three (3g) of pulverized onion sample was weighed into a thimble. The thimble was placed in the extraction unit of the soxhlet apparatus. About 230ml of petroleum ether was poured into a pre-weighed round bottom flask. The apparatus was set to boil at 80°C for 4 hours after continuous reflux of condensed solvent through the sample in the extraction thimble. The oil content was calculated using the formula: % oil content = (weight of oil extracted ÷ weight of sample) x 100%.

Determination of Protein Content

Crude Protein Content was determined as described by Kjedhal procedure in AOAC method 2006. Approximately 0.5g of pulverized sample was weighed into digestion tube, followed by addition of Kjedhal table (catalyst) then 15ml of concentrated hydrochloric acid was added. The mixture was digested at 420°C on digest stove. After digestion (clearly solution), a 40% sodium hydroxide solution was suctioned into it; then a distillation process involving the solution mixture and boric acid was made through continuous flow of distilled water in the distillation set-ups. After about 50ml of distillate was collected into the boric acid, the distillate was then titrated with 0.05M HCl using mixed indicator of bromo-cresol green and methyl red.

Protein composition was calculated as: $\text{protein (\%)} = \dfrac{(A-B) \times 0.05 \times 1.4007 \times 6.25}{\text{Weight of sample used (0.5g)}}$

Where A = titer value of sample (ml); B = titer value of blank (ml)

Molarity of HCl used = 0.05M; 1.4007 = equivalent of atomic mass of Nitrogen

6.25 = conversion factor of nitrogen.

Determination of Total Phenolic Content

Extraction of aliquot

About 500mg of pulverized onion sample was added to 25ml of methanol-water (80:20v/v) and then sonicated for 1hour. The mixture was then centrifuged at 3000g rpm for 30minutes and extract was collected twice after being spun for the second time into Eppendorf tube and completely wrapped with aluminium foil ready for analysis.

Gallic Acid Standard Preparation

12.5mg of gallic acid crystal was weighed and dissolved in 50ml volumetric flask made up to mark methanol-water (50:50) to produce a stock solution of 250mg/L which was then used to produce solutions of 50, 100, 150 and 200mg/L.

Determination of Total Phenolic Contents

Total polyphenols contents (TPC) were determined by the Lachman *et al* (2003) method and expressed in mg gallic acid equivalent(mg/dl) of dried weight matter. 0.25ml of 500mg/L solution of each sample was added to 2.5ml Folin Ciocalteu Reagent (FCR) followed by 2.0ml of 1M sodium carbonate. Likewise, 0.25ml of each of the gallic standard solutions were used in lieu of sample to obtain calibration curve; while 0.25ml of methanol-water (50:50) was used as blank in place of sample. The reaction mixes were allowed to stand at room temperature for 15minutes in a dim light room where the absorbance were then measured spectrophotometrically at 765nm using a T80 PG-UV/Vis spectrometer. TPC was expressed as gallic acid equivalent (GAE) mg/g fresh weight (FW) of sample.

Determination of Total Carotenoids

The total carotenoids were evaluated by the spectrophotometric method described by Chan and Cavaletto (1982). About 6g of pulverized onion sample was mixed with 5.0g of celite and 15ml Methanol(70%V/V) and then filtered using Whatman No 1 filter paper. The residue was extracted up to three times using 20ml of 1:1 acetone-petroleum ether (v/v). The extract was then transferred to 500ml separating funnel where a 5ml of 10% KOH (v/v) in methanol was added and mixture allowed to stand for 90minutes. Partition achieved following the addition of 15ml petroleum ether and 20ml NaCl (20%w/v) was separated as the hypophasic layer were discarded while the epiphasic (upper) layer was washed three times with 20ml of distilled water to remove excess acetone. It was then filtered through a funnel plugged with 3.0g anhydrous sodium sulfate to remove residual water. The filtrate was made up to 100ml petroleum ether and absorbance was measured at 450nm wavelength. The total carotenoids content (µg/g) was calculated using Beer-Lambert's Law equation: A = ECL Where A = absorbance, E = Extinction coefficient of carotenoids = 1.25x104 µg/L;

C = Concentration and L = path length of cuvette (1cm)

Data Analysis

Experimental analysis was carried out in triplicate and expressed as means ± standard deviation. Data were analyzed using the t-test (SPSS 16.0 version 2007) to determine the statistical significance ($p \leq 0.05$).

RESULTS AND DISCUSSION

Nutritional Composition of stored onions

To many, onion is just a spice for food delicacies. However, its nutritional compositions cannot be over emphasized. Macromolecules such as proteins, carbohydrates, lipid (oil) contents which are precursors of total derivable energy value for any form of food substance also constitutes a profile of nutritional exigencies in onion bulbs. The onions bulbs initially collected for this research was estimated to have energy value of 80.17Kcal/100g which steadily increases during the storage periods to 92.26Kcal/100g and 84.34Kcal/100g in the experimental structure tagged AAVSO and in the control respectively (Table 1). The normal body physiology is majorly dependent on derivable energy following cascades of metabolism of protein, carbohydrates and lipid asides other micro and macronutrients. From Table 1, the observed increase in carbohydrates were quite more than it was observed in protein and oil contents. Many food substances have showed increase in protein and carbohydrates as moisture contents declines due to concentrated linkages in the amino groups and glycolytic bonds respectively (Tao and Linchun, 2008). The decreasing moisture content were due to tissue respiration of onion bulbs and was more observed with the AAVSO due to steady aeration of the storage environment.

Table 1: Some Nutritional Parameters and Energy Value of Fresh Red onion in Storage

Storage Time	**Moisture (%)**		**Protein (%)**		**Total Carbs (%)**		**Oil (%)**		**Energy Value (Kcal/100g)**	
Month	AAVSO	Control	AAVSO	control	AAVSO	control	AAVSO	control	AAVSO	control
0th	78.39 $\pm0.01^{e}$	78.39 $\pm0.01^{e}$	1.95 $\pm0.1^{g}$	1.95 $\pm0.10^{g}$	15.35 $\pm1.0^{h}$	15.35 $\pm1.00^{h}$	0.93 $\pm0.0^{a}$	0.9$\pm$ 0.01^{a}	80.17	80.17
2nd	71.10 $\pm0.0^{g}$	75.02 $\pm0.01^{d}$	2.27 $\pm0.1^{d}$	2.22 $\pm0.06^{b}$	15.99 $\pm2.0^{d}$	15.53 $\pm1.50^{a}$	1.13 $\pm0.0^{e}$	0.95$\pm$0 .01^{h}	83.21	79.55
4th	65.17 $\pm0.83^{f}$	69.91 $\pm0.1^{a}$	2.47 $\pm0.0^{e}$	2.35 $\pm0.06^{c}$	16.80 $\pm2.0^{e}$	15.88 $\pm1.9^{b}$	1.18 $\pm0.0^{c}$	0.99$\pm$0 .02^{g}	87.70	81.83
6th	61.79 $\pm0.01^{b}$	65.03 $\pm0.0^{f}$	2.58 $\pm0.0^{a}$	2.47 $\pm0.01^{f}$	17.34 $\pm0.0^{c}$	16.22$\pm$ 0.0^{c}	1.22$\pm$ 0.01^{f}	1.02$\pm$0 .01^{c}	92.26	84.34

Values are data expressed as mean ±SD of three replicates. Different superscript in the same column indicates significant difference at $P<0.05$. AVO= Artificially Ventilated Onions; nCVO = normal Crib Ventilated Onions.

Bioactive Composition of stored onions

The onion for this study was analysed only for ascorbic acids, total polyphenolics and total carotenoids from among many known bioactive compounds of onion bulbs. Prior to storage, the onions were analysed to have 6.21±0.05 mg/100g, 5.10±0.02GAE (mg/g) Fresh weight and 1.02±0.00 µg/g contents of Ascorbic acids, total polyphenols and total carotenoids respectively. Fruits and vegetables with less moisture content as a result of dehydration tends to increase some bioactive compounds (Jayeeta, *et al*.,2012, Bala *et* al., 2021). Although the composition and concentration of any bioactive compounds are dependent of certain intrinsic and extrinsic factors such as genetic and cultivars, soil and growing conditions, maturity status and postharvest storage conditions (Chaudhary, *et al.*, 2018). Ascorbic acids have been reported to be thermo-labile and photo-sensitive which are prone to degradation on thermal processing and storage (Jayathunge *et al.*, 2019). Table 2 above depicted the initial estimated value of ascorbic acids to be 6.21±0.05 mg/100g prior to storage. However, there was steady decline from this initial value to 3.20±0.05 mg/100g and 2.86mg/100g in the artificially ventilated onions and the control onion respectively. This indicated that ascorbic acid declined more in the normal crib ventilated onions. This difference could be due to subsequent increase in temperature in the control structure than in the artificially ventilated structure during the

March- July period of storage in Kano state, Nigeria. Similarly, total carotenoids were initially estimated to be 1.02±00µg/g before storage. There was continuous decline in the total carotenoids contents of the onion during the storage periods but no significant ($p>0.05$) difference in the AAVSO and control respectively. Carotenoids are less affected compared to ascorbic acid levels during storage of fruits and vegetables (Jayeeta, *et al*.,2012). The total polyphenol contents of the onions were extrapolated from the equation: $y= 0.0053x+ 0.0023$; $R^2 = 0.9986$) of gallic acid standard as shown in figure 1. It was observed that total polyphenolic content increased from the initial estimate of 5.10±0.02GAE (mg/g) fresh weight prior to storage to 12.08±0.00 GAE (mg/g) FW and 9.95±1.03GAE (mg/g) FW in the artificially ventilated onions and the normal crib ventilated onions respectively. There was significant ($p<0.05$) in the value of total polyphenols in each periodic analysis from both onion structures. The AAVSO retained a 41.8% more of the total polyphenols than the control. This could be attributed to a less moisture content, lower temperature difference in the artificially ventilated onion structure than the normal crib onion structure.

Table 2: Some Bioactive Parameters of Fresh Red onion in Storage

Storage Time (Months)	Ascorbic acid (mg/100g)		Total polyphenols (GAE mg/g) FW		Total carotenoids (µg/g)	
	AAVSO	control	AAVSO	control	AAVSO	control
0th	6.21 ± 0.05^{a}	6.21 ± 0.05^{a}	5.10 ± 0.02^{a}	5.10 ± 0.02^{a}	1.02 ± 0.00^{b}	1.02 ± 0.00^{b}
2nd	5.40 ± 0.11^{c}	5.00 ± 0.02^{g}	5.61 ± 0.11^{b}	5.65 ± 0.05^{d}	0.77 ± 0.01^{e}	0.77 ± 0.01^{e}
4^{th}	4.80 ± 0.00^{e}	4.11 ± 0.05^{d}	9.04 ± 0.05^{e}	6.09 ± 0.11^{e}	0.53 ± 0.12^{f}	0.53 ± 0.00^{f}
6^{th}	3.20 ± 0.05^{d}	2.86 ± 0.11^{e}	12.08 ± 0.00^{d}	9.95 ± 1.03^{b}	0.07 ± 0.05^{a}	$0.069\pm0.\ 05^{a}$

Values are data expressed as mean ±SD of three replicates. Different superscript in the same column indicates significant difference at $P<0.05$. AVO= Artificially Ventilated Onions; nCVO = normal Crib Ventilated Onions.

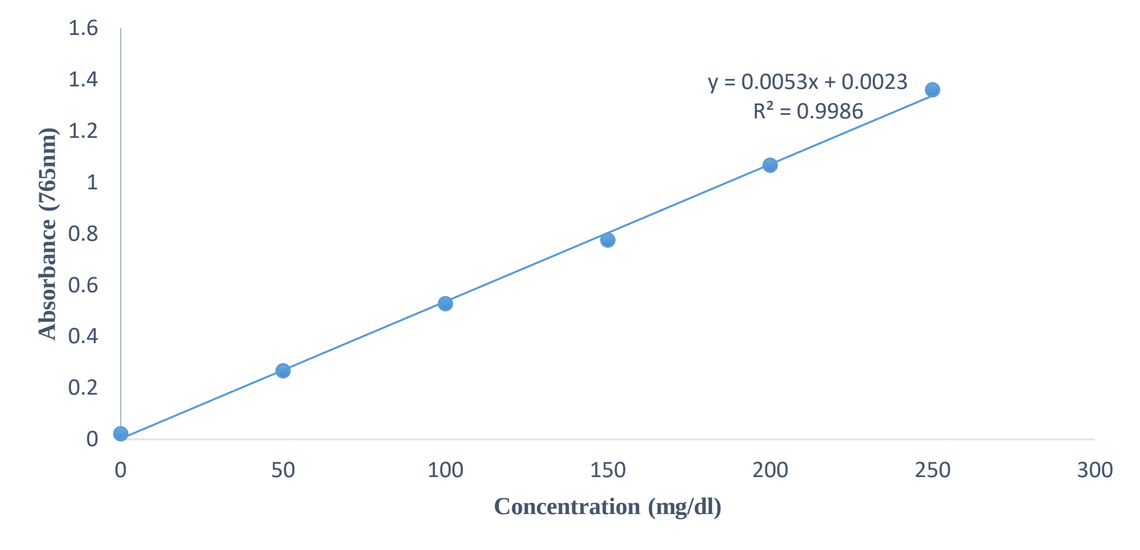

Figure 1: Plot of Gallic Acid Standard Absorbance (nm) Against Concentration (mg/dl).

CONCLUSIONS AND RECOMMENDATION

The study confirmed that there was more retention of the evaluated nutritional and bioactive compounds in the artificially ventilated onion structure than the control structure. Conclusively, onion storage in an artificially ventilated structure have shown to be more desirable to curb the enormous wastage during glut and for better retention of more nutritional and bioactive compounds prior to use at home or industry. It is therefore pertinent that policy makers and non-governmental organizations should encourage and support a larger scale onion storage in an artificially ventilated structure.

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Effects of Different Storage Methods on the Yield of living stone potato (*Plenthrantus esculentus*)

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ABSTRACT

A three year study was conducted at the National Root Crops Research Institute Umuahia Abia State to evaluate the different storage methods of living stone potato and as well affect the yield potentials. Early sprouting and rot are the major problems of living stone potato post-harvest storage. The objective was to determine the effect of different storage methods on reduction of early sprouting that will affect the yield potentials of the crop .The experiment was conducted in two stages; the first stage was the screening stage while the second stage involved field evaluation. Nine storage method used in the first stage were; bamboo raised platform , raffia palm raised platform, pit with wood shaving, pit with saw dust, pit with river sand, pit with wood ash, pit with rice husk , cemented floor, floor under shade of a tree and buried in the field,(control or farmers method), .In the second experiment pit with saw dust and cemented floor were screened out of the nine storage methods adopted due to their storage inefficiency .In 2016, seven (7) the treatments were evaluated in the field and were laid out in a randomized complete block design (RCBD) with three replicates. During the first stage of the experiment, significant differences were observed ($P<0.05$) in the percentage sprout count. The highest mean for both years were observed in cemented platform(17%) and pit with saw dust (16%). The highest mean percentage reduction sprout count was obtained in pit rice husk (99.5%) followed by pit with river sand (99.0%) while the least was recorded in cemented platform (83.3%) and pit with sawdust (83%).The field evaluation revealed that the tuber stored with rice husk (2 t/h) and that of river sand (2.60 t/h) gave the highest yield. The lowest yield were observed in the tubers buried in the field (0.78 t/h) and those stored in the bamboo raised platform(0.85 t/h). For effective storage of living stone potato for maximum yield, storing the tubers in pit with rice husk and pit with river sand maintained in a 60cm deep with 1mx1m is therefore recommended.

Keywords : Livingstone potato, storage methods, Postharvest, early sprouting.

INTRODUCTION

Living stone potato (*Plenthrantus esculentus*) or Rigza is one of the underutilized crop species which are very nutritious for both human and animals, the tubers are often used for substitute for potato or sweet potato. (Olojede, *et al.*, 2004). It is a dicot perennial herb and a member of a *lamiaceae* family. It is indigenous to Africa where it is grown for its nutritious edible tubers .The leaves contain a lot of vitamins and can help in digestive problems and abdominal pain.(Alleman and Coertze,1997). The tubers are mostly boiled but can be roasted baked, or fried ,it is rich in carbohydrate, vitamin A, mineral and essential amino acid. (Lukhoba *et al*,2006) . Early sprouting and rot are the major problems of living stone potato during post-harvest storage. The end of dormancy leads to initiation of sprouting which in turn means increased respiration and dry matter loss. It also determines the factor, on how long the commodity can be stored (Soctt, *et al.*, 2000). The use of different storage methods implies a strict control of environmental temperature and humidity in the storage chamber (Treche and Agbor-Egbe,1996). It is important to determine the best storage method that will control or reduce an early sprouting in living stone potato. The objective was to determine the effects of different storage methods on reduction of early sprouting and yield performance of Rizga.

MATERIALS AND METHOD

First Stage: The study was carried out in NRCRI, Umudike 2014 and 2015 cropping seasons for four months of each year. Nine different methods used were as follows; Bamboo raised platform , raffia raised platform, pit with wood shaving, pit with saw dust, pit with river sand, pit with wood ash, pit with rice husk ,buried in the field (control) cemented floor and floor under shade. Twenty 20 kg each of living stone potato and storage materials (sand, wood ash, rice husk, wood shaving and saw dust) were weighed out for the pit treatments . The weighed materials were poured inside the pit which was maintained at 60 cm deep and 1 m x 1 m size . They were mixed with the weighed tubers inside the pit. Moreover the tubers were also buried in the field and covered with soil (control or farmers method) ,the cemented floor under and floor under shade of a tree, raised platform of bamboo poles and raffia fronds also received the same quantity of weighed tubers of living stone potato . The storage sites were visited every two week interval to record Percentage sprout count and cumulative percentage.

Second stage : In 2016 two methods (pit with saw dust and cemented floor) were screened out of the nine storage methods adopted in 2014 and 2015 due to their storage inefficiency .The seven storage methods were evaluated in the field, after clearing the existing vegetation ploughed, harrowed and ridged. The field was demarcated into different plots of 2 m x 2 m with three replicates, plant spacing was 0.3 m x 1 m laid out in randomized complete block design (RCBD). All other agronomic practices were done and data were collected as at when due and subjected to analysis of variance. Means were separated with least significant difference (LSD<0.05).

RESULTS AND DISCUSSION

During the first stage of the experiment (Table1), significant differences were observed (P<0.05) in the percentage sprout count. The highest mean for the years were observed in cemented platform (17%) and pit with saw dust (16%). Consequently, one percent stand count (1%) was further observed on the following storage methods; pit with river sand, buried in the field and pit with rice husk. This also reflected in the percentage reduction sprout count. The highest mean was obtained in pit rice husk (99.5%) followed by pit with river sand (99.0) while the least was recorded in cemented platform (83.3%) and pit with sawdust (83%).

Table 2 depict the evaluation of the seven methods in the field, it was observed that the tuber stored with rice husk (2 t/h) and that of river sand gave the highest yield (2.60 t/h) . The lowest yield were observed in the tubers buried in the field (0.78 t/h) and those stored in the bamboo raised platform (0.851t/ha). The highest value obtained in storage with rice husk could be due to its bio-energy products that has a high count of cellulose and lignin according to Sheng ,(2000),this attributes contributes to the storage and yield of agricultural products. The highest yield obtained in river sand could be as a result of its cooling and drying effect on the tuber, thereby maintaining the temperature of the micro environment which result to an efficient reserve of energy from storage to the field, this confirmed the work done by Treche and Agbor-Egbe,(1996).They stated that biochemical changes during storage can affect the yield potential of tubers. The lowest value obtained in the yield of tuber stored in a raffia palm (1.05 t/h) could have resulted due to the dryness of the palm leaves after a period of time of storage which perhaps allowed the sun to penetrate towards the stored tubers which must have affected the storability and physiological components of the tubers..

CONCLUSION /RECOMMENDATION

In the first two years of the experiment there was an evidence that four storage methods (buried in the field, pit with rice husk ,pit with river sand and pit with wood ash) among the nine methods gave a better result than other storage methods, this was because their percentage sprout count reduction was above 90%. After the evaluation in the field, pit with river sand and pit with rice husk gave the highest yield in t/ha. The two methods also gave potential post-harvest storability. Therefore for effective storage of living stone potato for maximum yield, storing the tubers in pit with rice husk and pit with river sand maintained in a 60 cm deep with 1 m x 1 m is recommended.

Table1. Effects of Different Storage Methods on Percentage Sprouting of Living Stone potato

Storage methods	% Sprout count			% Reduction sprout count		
	2014	2015	mean	2014	2015	mean
Floor under shade	3.00	4.00	3.50	97.0	96.0	96.5
Cemented platform	16.30	17.43	17.0	83.7	82.6	83.3
Buried in the field	1.66	0	1.66	90.8	100	95.0
Rafia palm raised	9.30	10.7	10.0	90.7	89.3	90.0
Pit with river sand	1.40	1.20	1.30	99.0	99.0	99.0
Pit with Rice husk	1.00	0	1.00	99.0	100	99.5
Pit with saw dust	15.0	17.0	16.0	85.0	82.0	83.3
Pit with wood ash	4.66	6.80	5.73	95.3	93.2	94.2
Bambo raised platform	5.00	5.81	5.40	95.0	94.2	95.0

LSD 0.05	**2.83**	**2.80**	**NS**	**NS**

Table 1.Effects of the Storage Methods on the Yield of living stone potato

Treatments	**Total no. of tubers/plot (3 sampled plant)**	**Yield/ tonnes/ha**
Buried in the field	18.05	0.780
Pit with Rice husk	21.60.	2.031
Pit with wood ash	28.45.	1.080
Pit with river sand	34.38	2.60
Pit with wood shavings	27.01	1.860
Raffia raised platform	21.22	1.050
Bamboo raised platform	19.01	0.851
LSD 0.05	**2.21**	**0.34**

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Effect of spices on the nutrional and mineral composition of oven-dried *Clarias gariepinus in Alimosho Lagos.*

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ABSTRACT

The study was conducted to know the nutritional implication of Ginger-garlic spices on the oven-dried C. gariepinus.Analysis of variance (ANOVA) using F-test was used to determine the treatments level of significance. The samples were divided into Two (2) batches, Sample A (Fresh catfish), and Sample B (Spiced oven-dried catfish (garlic- ginger mixed). The proximate and mineral compositions of the both samples were determined. The research work shows a significant difference $P < 0.05$.in the percentage of Moisture, Ash, Crude fibre, Fat, Protein, Total carbohydrate and energy value of fresh fish and spiced-oven dried C. gariepinus with the mean values of 58.10±0.17, 5.32±0.02, 0.14±0.02, 6.95±0.15, 27.39±0.11, 2.11±0.40, and 180.51±0.47 for fresh fish and 13.91±0.16, 6.42±0.09, 9.10±0.13, 10.09±0.22, 41.97±0.11, 18.53±0.32, and 331.01±1.93 respectively for spiced oven-dried fish. The significant increase in Protein, ash, lipid and fibre content of the spiced oven-dried sample might be as a result of the change in moisture content and the inclusion of Ginger-garlic spices to the sample respectively. The mineral contents of the fresh fish to spiced oven dried fish indicated an increased significant difference $P < 0.05$ in Calcium and Iron with the mean value from 74.07±0.03 to 126.01±0 and 3.46±0 to 5.88±0 respectively. Hence, a ginger-garlic spice enhances the nutrient and mineral composition of oven-dried Clarias gariepinus.

Keywords: Spices, chemical properties, mineral components, *Clarias gariepinus*

INTRODUCTION

Fish is said to be a very good source of animal protein rich in essential amino acid and has been generally accepted as a good source of protein and other elements for the maintenance of healthy body (Ryu *et al*., 2011; Hegazy *et al*., 2011). *Clarias gariepinus*, one of the species of catfish is a highly nutritious fish that contain high amount of vitamins, proteins, minerals and a little or no saturated fat, and is low in carbohydrates (Idris, 20I0). It is an economically important freshwater fish, and enjoys wide acceptability; it is extensively cultivated in ponds but is sometimes underpriced (Kumolu-Johnson, 2010). Furthermore, as important as fish is, high degree of fish spoilage still occur in Nigerian due to the absence of storage facilities and this serves a major constraint to the development of fishing industry in Nigeria. Bellagha *et al.*, (2007) reported that due to the perishable nature of fish, traditional methods of preservation have been developed over the years which include salting, drying and smoking. The importance of fish smoking differs but in Nigeria, the process has proven relevant to prolonging shelf-life, enhancing flavour and increasing protein availability to people throughout the year (Kumolu-Johnson *et al.*, 2011). The fish could be spiced to enhance flavor and nutrient availability. According to Ayeloja *et al.*, 2013, spices (ginger, onion, garlic, etc.) are edible plant materials that possess anti-oxidant, antiseptic and bacteriostatic properties. They are added to foods to delay onset of deterioration, such as rancidity, and also function as seasonings to foods as well as impart flavor to the foods (Abdel-Hamied *et al.*, 2009). Ginger as a spice has a geographical spread that covers every part of the globe and it is consumed whole as a delicacy, used in traditional oriental medicine, or as spice in foods, such as fish (Onyeagba *et al.*, 2004). Garlic is one of the most used natural ingredient to enhance flavour in food. It has a wide spectrum of actions, which include: antibacterial, antifungal and anti-oxidative. It also has a beneficial effect on cardiovascular and immune system of human (Sallam 2004). Ginger contains spectra of biologically active compounds, such as curcumin, 6-gingerol, 6-shagaols, zingiberene, bisabolene and several other types of lipids that confer on it, the properties of being pungent and a stimulant. However, these compounds are responsible for the unique aroma and flavour of ginger, and account for about 1-3% of the weight of fresh ginger (Akram *et al.*, 2011). This study was therefore carried out to investigate the effect of spices on the chemical and mineral properties of smoked catfish.

MATERIALS AND METHOD

Fish and preparation

Twenty five (25) live catfish (*Clarias gariepinus*) were purchased from a reputable farm at command, Alimosho Lagos. The samples were immediately transported in an oxygen bag to the Sofunk foods processing unit Ajasa command, Alimosho, Lagos for smoking and the rest samples to Federal Institute of industrial Research chemistry laboratory, Oshodi Lagos, for chemical analysis. The samples were divided into Two (2) batches, Sample A (Fresh), and Sample B (Spiced oven-dried). The spiced (garlic- ginger) ingredient were properly cleaned, washed and blended in an electrical grinder machine to produce their juice and it was stored in a refrigerator prior use. However the samples were degutted, cleaned and soaked in garlic: ginger juice (spiced) for 15min after which were oven-dried for 48hrs at the temperature of 40-70^{0}C using a smoking kiln. Hence the oven-dried spiced catfish was allowed to cool for 8hours prior further chemical analysis.

Chemical Analysis: The proximate composition of the fish samples was determined using the standard methods of AOAC (2005). The minerals were determined using Atomic Absorption Spectrophotometer (AAS). The samples used for the analysis were assayed in triplicate.

Statistical Analysis: Analysis of variance (ANOVA) was carried out using F-test to determine the treatments level of significance. Treatments were separated using Duncan Multiple Range Test (DMRT) at 95%.

RESULT AND DISCUSSION

Table 1: Proximate composition of fresh and spiced oven-dried Catfish (*Clarias gariepinus*)

	A	B
Parameter (%)	**Mean ±SE**	
Moisture	58.10±0.17[b]	13.91±0.16[a]
Ash content	5.32±0.02[a].	6.42±0.09[b]
Crude fibre	0.14±0.02[a]	9.10±0.13[b]
Fat content	6.95±0.15[a]	10.09±0.22[b]
Protein content	27.39±0.11[a]	41.97±0.11[b]
Total carbohydrate	2.11±0.40[a]	18.53±0.32[b]
Energyvalue (kcal)	180.51±0.47[a]	331.01±1.93[b]

A – Fresh catfish, B- Spiced oven-dried catfish, SE – Standard error, Kcal- kilocalorie
Means on the same row followed by the same letter are not significantly different at $P < 0.05$.

Table 2: Mineral composition of fresh and spiced oven-dried Catfish (*Clarias gariepinus*)

	A	B
Parameter (ppm)	**Mean ±SE**	
Calcium	74.07±0.03[a]	126.01±0[b]
Potassium	74.41±0.01[c]	74.35±0[b]
Magnesium	41.81±0[a]	42.62±0[b]
Sodium	251.52±0.01[a]	295.34±0.01[b]
Zinc	2.39±0[a]	3.10±0[b]
Iron	3.46±0[a]	5.88±0[b]
Chromium	1.02±0[a]	1.34±0[b]

A – Fresh catfish, B- Spiced oven-dried catfish, SE – Standard error, ppm – part per million
Means on the same row followed by the same letter are not significantly different at $P < 0.05$.

The proximate composition of fresh and spiced oven-dried catfish was presented in Table 1 Moisture content of fresh catfish has the highest value of 58.10±0.17 and spiced oven-dried catfish was represented by a low value of 13.91±0.16. Ayeloja *et al.*, 2013 reviewed that, the differences in moisture content could be due to variation in the moisture absorbing properties of the spices applied before smoking. The resultant reduction in the moisture content of the smoked fish products will prolong the shelf life of the products. This is in line with the findings of Fapohunda and Ogunkoya (2006), Daramola *et al.*, (2007) also reported that the removal of moisture content increased the shelf life of fish products. There is a significant increase in the protein of fresh catfish from 27.39±0.11 to 41.97±0.11 when oven -dried with spices. The results, indicated that the crude protein in the mean proximate composition formed the largest quantity of the dry matter in all the fish products and this is in line with the report of Ajani *et a1.*, (2013) stating that crude protein formed the largest quantity of the dry matter in all fish. The significant increase in protein levels, when compared with the fresh fish, suggests that protein nitrogen was not lost during oven-drying. This is in accordance with the findings of

Puwastien *et al.*, 1999; Gokoglu *et al.*, (2004); Tao and Linchun (2008) and Foline *et.al.*, (2011). Hence the result of the crude fibre content shows that the fresh fish had the lowest value with a mean value of 0.14±0.02 which was significantly different ($p < 0.05$) from spiced oven-dried catfish. However, this might be a product which is a function of fibre content of the spices applied to the fish product before smoking. Ash is the inorganic residue resulting from the removal of moisture and organic matter by applying heat treatment. Mineral content in food is also represented by ash content (Kurniaty *et al.*, 2018). Higher ash content indicates a higher value of mineral composition for human health (Magara *et al.*, 2020).Thus, these concentrations of minerals and trace elements may be different due to feeding behaviour, environment ecosystem and migration (Andres *et al.*, 2000). Spiced oven-dried fish fat indicates a significantly different higher mean value of 10.09±0.22 than the fresh fish (6.95±0.15) sample. Hence, the increase might be due to reduction in moisture content during smoking as reported by (*Ogbonnaya and Ibrahim* 2009; Tenyang *et al*., 2020).

The result of the mineral composition presented on Table 2 indicated that the spiced oven-dried smoked fish were rich in calcium with the spiced product having the highest value of calcium (126.01±0), while the fresh fish had the lowest calcium value (74.07±0.03). Calcium is required in maintaining and building bone and tooth, and also performs the functions of adjusting the acid-base balance, blood coagulation and transportation of nerve impulses (Meta *et al.*, 2010). The spiced oven dried catfish having the highest level of iron, while the fresh having the lowest mean value. This result is in conjunction with the work of Ayeloja *et al.*, 2013. Iron supply is needed for the bounding of hemoglobin therefore iron took an important role by oxygen transportation (Meta *et al.*, 2010). Generally, the minerals occurred at low levels within international limits, thereby making this fish product safe for consumption. Magnesiun, Sodium, zinc, iron and chromium have higher value in this study, but are not above the recommended value.

CONCLUSION

The result of this study shows significant differences ($p < 0.05$) in the nutritional composition and mineral contents of fresh and spiced oven-dried catfish products. However, addition of Galic-ginger spices improves the nutritional value of protein, Ash, fiber and fat content as well as the mineral contents of the products because low moisture content of the spiced fish product, enhances the increase in the nutritional composition of the product. Hence the use of spices (garlic-ginger) in the present study added quality value to spiced oven-dried fish products.

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Toxicological Effects of Short-term Exposure of Rat to Arsenic and Protective Role of Ginger (*Zingiber officinale)*

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ABSTRACT
Arsenic is an environmental toxicant, and the exposure can occur through the workplace and food. due to arsenic toxicological effects, exposure to humans can cause degenerative disorders. this study examined the toxic effect of arsenic and the protective roles of ginger (zingiber officinale) on experimental rats exposed to arsenic. animals were divided into three groups: the control group that received the normal feed, the arsenic group fed with arsenic-contaminated feed, and the arsenic + z. officinale group that received arsenic-contaminated feed with zingiber officinale for 90 days. the animal's percentage weight, hematological analysis, biochemical evaluation, and dna damage in comet and micronucleus assays were determined. the results were analysed using the graph pad prism. results obtained revealed that co-administration of arsenic contaminated feed with zingiber officinale decreased the weight of the animals. when compared to zingiber officinale and control group, the results showed that exposure to arsenic for 90 days decreased the amounts of white blood cells and red blood cells. the result showed a significant increase in liver enzymes (ast, alt and ggt), and arsenic contaminated group also had higher levels of urea and creatinine than expected. normal and arsenic–contaminated groups in the treated group showed a significant difference. arsenic was shown to affect hepatocytes and caused dna damage in comet and increased %mnpce in micronucleus assay however co-administration of zingiber officinale restored the hepatocytes to normal and decreased the level of %mnpce. this study demonstrated that eating foods polluted with arsenic has toxicological consequences on the body but adding spices like zingiber officinale to regular meals can protect us from these effects.

Keywords: Arsenic, *Zingiber officinale*, Body weight, Hematology, Biochemical analysis, Genotoxicity

INTRODUCTION
When compared heavy metals to water, the metallic elements with a comparatively high density of metals are referred to as heavy metals (Alam et al., 2020). Heavy metals also include metalloids like arsenic, which might have low toxicity when exposed to the environment and on the basis of its heaviness and toxicity (Luo *et al.*, 2020). The public health issues brought on by the environmental degradation by these metals have gotten worse in recent years. Due to the exponential rise of a variety of industrial, agricultural, residential, and technical applications, exposure to organisms has also substantially expanded (Proshad *et al.*, 2020).

Heavy metals are divided into two essential and non-essential categories. Essential heavy metals, also referred to as micronutrients, include; cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn), and are needed for a variety of biochemical and physiological processes (WHO/FAO/IAEA, 1996)

One example of heavy metal is arsenic. It is a common element that can be found in soil, water, food, air and it comes from both natural and artificial sources, and it is also released into the environment. Arsenic consequences range from immediate death to long-term ones like cancer and cardiovascular disorder. Based on known or suspected toxicants, arsenic is ranked first among toxicants that pose a significant risk to human health (Zheng *et al.*, 2022).

The spice ginger (*Zingiber officinale*) is one of the most popular in the world. It has a long history of use as herbal remedy for conditions like indigestion, discomfort, vomiting, and cold-induced disorders (Zhang *et al* 2021). Ginger is well known for its antioxidant, and anti-inflammatory, and anticancer properties. The volatile oils and different phenolic compounds like gingerols, shogaols, zingerone, and gingiberols are regarded to be the active ingredients in ginger. One potential mechanism for scavenging oxygen free radical and reducing the generation of reactive oxygen species (ROS) has been identified as the antigenotoxic activity of ginger (Celik, 2020). This study was done to determine the toxicological effects of short-term exposure of rat to arsenic and protective role of ginger (*Zingiber officinale)*

MATERIALS AND METHODS

Plant collection and Identification: From the area of Sabo Baptist Church Market, in Ogbomoso, *Zingiber officinale* was gathered. It was blended into a powder at the market and packaged for the animal.

Experimental Animal: Seventeen male Wistar rats (weighing between 120-160grams) were bought from Mama Rat Animal Holding in Ogbomoso, Oyo State. Animals were maintained in polycarbonate cages and placed in the animal house under regular conditions. They have undergone two weeks of acclimatization in a chamber with 12hour light/12hour dark photoperiod schedule at a temperature of 32 ± 2°C. The normal group received only food, the second group received food infected with arsenic and the third group received food infected with arsenic + ginger

Contamination of feed with heavy metal: Feeds + Heavy metal (Arsenic) + Supplement or Spices (ginger)

Feed contamination is accomplished by combining the heavy metal and the feed's raw powder separately. Following the addition of spices, the final combination is then converted into granules for the rats to easily consume at the Ladoke Akintola University of Technology Ogbomoso animal house.

Biochemical analysis: Prior to biochemical analysis, the clot-filled blood in the lithium tubes was spun at 3000 g for 10 min to separate the serum (supernatant) and stored at −70 ◦C. WBC, HGB, HCT, RBC, PLT, and %LYM were the hematological parameters that the obtained blood was examined for using an auto analyzer. Standard techniques were used to evaluate the serum biochemical indicators, according to Constantino, Serum functional test indicators for the liver and kidneys were measured (Constantino, 2017). Utilizing HAICE®, DR 3000, (Germany), the absorbance for each reaction were determined spectrophotometrically. Jiraungkoorskul et al., 2007's protocol for the micronucleus and comet assay was followed.

Statistical Analysis: Microsoft Excel and Graph pad prism 5 were used for the statistical analysis. Analysis of variance was used to analyze the outcome (One way ANOVA).

RESULTS

Percentage change in body weight of rats fed with Arsenic-contaminated feed after 90 days of exposure.

Table 1: As shown in this table, the percentage weight growth of rats fed with arsenic contaminant feed decreased significantly from 30 days to 90 days as compared arsenic-contaminated with *Z.officinale* to normal group. There was a significant difference when compared arsenic to arsenic + *Z.officinale* after 90days of exposure.

	% Body weight gain		
Group	30days	60 days	90 days
Normal	21.66[a]	4.88[a]	4.26[a]
Arsenic-contaminated feed	27.91[b]	15.64[b]	12.17[c]
Arsenic-contaminated feed + Ginger	25.84[a]	15.39[b]	8.71[b]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

Normal control

a- Not significantly difference when compared treated group to normal

b- Significantly difference when compared arsenic and arsenic+ *Z.officinale* to normal

c- Significantly difference when compared the arsenic to arsenic+ *Z.officinale*

The effect of Arsenic and *Z.officinale* on the hematological parameters of Rats.

Table 2: The data from this table below indicated how *Z.officinale* and arsenic affected the rat's hematological parameters. After 90 days of exposure, the arsenic contaminated feed group and arsenic contaminated with *Z.officinale* group showed a significantly lower levels of WBC, RBC and other parameters as compared to the control group (p<0.05). After 90 days of rat exposure, there was no significant difference between the arsenic contaminated feed group and the normal control group in RBC, HGB and PLT (p<0.05). However, there was no significant different when compared arsenic and arsenic with *Z.officinale* in RBC, HCT and HGB.

Parameters	**Duration**	**Normal**	**Arsenic-contaminated Feed**	**Arsenic contaminated feed + Ginger**
WBC(X10^3)/µL	30 days	15.63±1.09	12.60±1.97[b]	10.23±1.89[b]
	60days	15.06±1.71	10.59±1.03[b]	13.98±0.81[a]
	90 days	11.25±1.45	4.40±0.46 [b]	5.56±0.52[a]
RBC(X10^6) µL	30 days	29.83±0.35	23.10±0.44[a]	26.93±0.97[a]
	60days	6.08±0.22	3.28±1.60[b]	6.22±0.30[a]
	90 days	8.16±0.28	6.60±0.45[a]	7.12±0.34[a]
PLT (X10^3	30 days	754.0±126.0	500.0±53.80[b]	615.3±106.7[b]
	60days	974.3±238.8	628.6±110.6[b]	769.0±123.2[b]
	90 days	533.2±61.89	340.7±10.00[b]	402.3±55.72[b]

	30 days	50.40±1.30	31.53±2.20 [a]	40.47±1.68[a]
	60days	15.06±1.70	10.59±1.02 [b]	13.98±0.81[a]
HCT	90 days	47.27±1.48	36.30±2.40 [a]	39.63±0.92 [a]
	30 days	15.07±0.47	12.07±0.47 [a]	14.90±0.61 [b]
	60days	16.74±0.21	12.37±3.09 [b]	13.83±9.83 [b]
HGB	90 days	10.63±0.20	7.15±0.65 [a]	9.57±0.23 [a]
	30 days	79.93±3.11	69.83±3.51[a]	76.40±10.37 [b]
	60days	71.06±2.69	50.06±10.81 [b]	65.58±0.68 [a]
%LYM	90 days	75.27±1.91	66.80±11.40[b]	74.80±5.87 [a]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

Normal control

a- Not significantly difference when compared treated group to normal
b- Significantly difference when compared arsenic and arsenic+ *Z.officinale* to normal
c- Significantly difference when compared the arsenic to arsenic+ *Z.officinale*

The Effect of Arsenic and *Z.officinale* on the hepatic function and renal function levels.

Table 3: The results showed that, when compared arsenic contaminated feed group to normal group, the levels of AST, ALT and GGT increased significantly, however, in the arsenic contaminated with *Z.officinale*, the levels of AST, GGT and ALT significantly increased when compared to normal group. The results from this table demonstrated a substantial difference in urea level and creatinine level between normal group, arsenic-contaminated diet and arsenic contaminated with ginger. When compared to the normal group, the arsenic-contaminated group and the arsenic-contaminated with *Z.officinale* group both have higher levels of creatinine. There was a significant difference when compared arsenic-contaminated group and the arsenic-contaminated with *Z.officinale* group in AST and ALT but there was no significant different in GGT.

GROUP	**AST(μ/L)**	**ALT (μ /L)**	**GGT (μ /L)**	**UREA**	**CREATININE**
NORMAL	50.93±6.63	69.79±7. 10	56.45±2.65	30.91±1.32	90.00±16.21
Arsenic contaminated feed	123.50±46.07 [b]	156.50±38.75 [b]	60.77±1.94 [a]	50.71±0.56 [a]	125.50±23.67[b]
Arsenic contaminated feed +Ginger	98.80±60.15[b]	104.80±95.22 [b]	58.71±5.93 [b]	45.94±8.52 [b]	107.00±80.67[b]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

The Effect of Arsenic and *Z.officinale* on the %MNPCE and % tail DNA of Rats fed.

Table 4: The results of this study demonstrated that after 90 days of exposure to arsenic, the %MNPCE level in the normal group dramatically increased when compared to arsenic contaminated group but there was little difference when compared to arsenic with *Z.officinale* group, whereas there was no significant different when compared arsenic to arsenic with ginger . According to the comet results, after 90days of exposure, there was a significant difference

between the arsenic-contaminated group and the normal group, but not between the arsenic contaminated + *Z.officinale* group and the normal group, while there was a significant different when compared arsenic to arsenic with *Z.officinale*.

Parameters	Duration	Normal	Arsenic	Ginger
Comet	30days	13.85±0.37	15.88±1.34[a]	14.96±0.30[a]
	60days	11.56±0.78	13.80±0.59[b]	12.12±0.13[a]
	90days	12.26±0.21	14.90±0.36[b]	13.19±0.36[b]
%MNPCE	30 days	2.90±0.22	3.89±1.08[b]	3.02±1.38[a]
	60 days	0.80±0.05	1.56±0.47[b]	1.48±0.57[b]
	90days	0.32±0.01	1.47±0.21[b]	0.55±0.05[a]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

DISCUSSION

Toxicants are ingested and are carried by the blood to many different organs, including the liver and kidney where they may have negative consequences in the body. In this study, the amount of weight growth experienced by rat fed with arsenic contamination and the healthy control group declines over time. According to recent studies, *Z.officinale* may help people lose weight and prevent obesity-related disorders (Suk *et al*, 2017). Hemolytic anemia, infections, inflammation-tissue necrosis and stress are examples of benign disorders that can result in Leukocytosis and thrombocytosis (Claire *et al.*, 2021). RBC, HTC and HGB levels in the exposed with arsenic rat group and arsenic+ *Z.officinale* group significantly decline with time from 30 to 90 days which is a sign of anemia which could be as a result of gastrointestinal tract bleeding suggesting that arsenic suppresses the immune system. According to Aysel *et al*, (2016), administration of arsenic+ *Z.officinale* result in the preservation of haematological parameters.

Because liver enzymes are secreted into the extracellular space by hepatocytes, they are employed as indictors of liver damage (Zhang *et al*, 2020). When hepatocytes are harmed or eliminated, the liver releases alanine and aspartate aminotransferases. When arsenic poisoning causes hepatocellular damage, the serum activity of these enzymes increases. Apart from the arsenic-contaminated diet mixed with *Z.officinale* in the exposed rat, liver enzymes AST and ALT were higher ($p<0.05$) in the arsenic exposed rat compared to the arsenic+ *Z.officinale* rat. According to Talpur *et al*, (2013), supplementing *Z.officinale* in rat diets as an alternative to antibiotics and therapeutic drugs had significantly as an additive and may improve the immune status of rats, however in GGT the exposed rats are significantly higher compared to arsenic+ *Z.officinale* rat. The arsenic contaminated exposed group shows a significant increase which trend in the exposure period of the rat when compared to arsenic+ *Z.officinale* rats. The micronucleus test is determined using %MNPCE in the blood of exposed rat and normal rat, arsenic-induced toxicity has been linked to a number of mechanisms, including the inhibition of several enzymes involved in DNA repair and expression, which are responsible for the types of genotoxic damage seen in this work (Andersen et al., 2018).

As a sensitive, quick and affordable method for detecting DNA strand breakage, the comet assay is an excellent non-specific indicator of genotoxicity in rats (Andersen et al., 2018). After 90 days, the amount of DNA damage found in the tissue of rats exposed to an arsenic contaminated diet increased. *Z.officinale* played a protective role which could lead to the decrease in the level of arsenic in the tissue which result in repaired DNA, the loss of cells with severely damage DNA, or both (Muller et al., 2021). The toxicology of a contaminant that could interfere with the enzymatic activities in the generation of DNA damage may be the cause of the inverse association between time of exposure and DNA damage (Muller et al., 2021).

CONCLUSION

These findings suggested that care should be given to long-term exposure to feed contaminated with arsenic. In this investigation, arsenic was specifically found in the rat liver as evidenced by the micronucleus assay that was carried out. *Z.officinale*, which has numerous biological properties including antioxidant, anti-inflammatory, antibacterial, anticancer, neuroprotective, hepatoprotective, cardiovascular protection, and antidiabectic, can be used to evaluate the degree of exposure and damage, potentially reverse these effects.

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Yam storage and storage structures: implications for postharvest control

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ABSTRACT

Yam (Dioscorea spp.) is the second most important tropical root crop in West Africa after cassava. Postharvest loss, which has largely been associated with lack of appropriate storage systems, is the most common problem faced by smallholder yam farmers. The high level of yam postharvest losses has become a serious economic and food security threat. Existing yam storage structures have all that is required of improved storage structures but the cost is a great disincentive to farmers, which has greatly affected their adoption over the years. Case studies were reviewed, general and common practices analysed. The analysis was approached under a broad categorization of traditional and modern methods. The findings revealed many traditional and modern storage structures in use by farmers in Nigeria. The study discovered that lack of finance accounted for the predominance of traditional methods. It is recommended that fund should be made available to farmers at zero or minimal interest rates. Also, more efforts should be made to educate farmers on the benefits of modern storage techniques.

INTRODUCTION

Yam is an annual crop, so for it to be available throughout the year, harvested tubers must be stored for six to eight months before new yams are harvested. The possibility to store fresh yam tubers is decisively influenced by their dormancy which occurs shortly after their physiological maturity (wilting point). During dormancy, the metabolic function of the tuber is reduced to a minimum. It allows the tuber as an organ of vegetative propagation to overcome an unfavourable climatic period. (Knoth J. 1993). During the storage period a substantial amount of yam is lost. Some of these losses are endogenous, i.e. physiological, and include transpiration, respiration and germination. Other losses are caused by exogenous factors like insects, pests, nematodes, rodents, rot bacteria and fungi on the stored product (Wilson, 1980). Good management can easily control the exogenous loss factors while the environment controls other sources of loss. In addition, Umogbai, (2013) pointed out that successful storage of yams requires the use of healthy and sound tubers, proper curing if possible combined with fungicide treatment, adequate ventilation to remove heat generated by respiration of sprouts and rotted tubers that develop. Monitoring the presence of rodents and protection from direct sunlight and rain is also necessary. Yams can be best stored in a cool, dry and well ventilated surrounding. The review highlighted selected traditional and modern storage structures in use by farmers in Nigeria.

Storage Yam

Yam storage structures and methods were evaluated in different zones of Nigeria (Osunde,. and YIsa, 2000; Adejumo, 1998). They come in different shapes and sizes depending on the ability of the farmer, locality and cultural practices. The construction materials are usually wood, ropes, palm fronds, guinea corn stalks, and mud (FAO, 2004; Umogbai and Satimehin, 2004). The most common problems faced by farmers are post-harvest losses. Umogbai (2013) opined that wastage occurs because the apparent surplus during the harvest season cannot be consumed within a short period. However, few months after the harvest, there is always a diminishing availability of yam produce. Therefore, it becomes imperative that the existing yam tubers are stored in structures for later use.

According to Opara (1999), there are several traditional low-cost storage methods and structures for yam tubers; the most common of them include leaving the tubers in the ground until it is needed, storing under tree shades, yam barns, underground structures such as pits, ditches and mud structures. Umogbai (2013) and Okoedo-Okojie and Onemolease (2009) also reported that there are well ventilated weather-proof, insect and rodent proof strong shelters for storage of yam tubers.

Storage structures usually depend on the construction material available, amount of tuber produced, prevailing climatic condition of the area, purpose of yam tuber storage, socio-cultural aspects of storage and the resources of the farmer, in particular the availability of labour and capital. In most rural yam producing areas, yam is stored in a yam barn which is the principal traditional yam storage structure in the major producing areas. Barns are usually located under the shade and constructed so as to facilitate adequate ventilation while protecting tubers from flooding, direct sunlight and insect attack. There are several designs, but they all consist of a vertical wooden framework to which the tubers are individually attached (Opara 1999; Igbeka 1985).

Yam Barn Yam Crip

Tubers are tied to a rope and hung on horizontal poles 1-2 m high (Figure 1); barns up to 4 m high are not uncommon. Osunde and Yisa (2000) asserted that depending on the quantity of tuber to be stored, frames can be 2 m or more in length. The ropes are usually fibrous; in southeastern Nigeria they are made from the raffia obtained from the top part of the palm wine tree. Many farmers have permanent barns that need annual maintenance during the year's harvest. In these situations, the vertical posts are often made from growing trees which are trimmed periodically. Palm fronds and other materials are used to provide shade. The vegetative growth on the vertical trees also shades the tubers from excessive solar heat and rain (Opara 1999). Figure 2 is a typical yam barn constructed from guinea corn stalk, sticks, grass and yam vines. The yams are heaped at different positions in the barn (Ijabo and Jirgba 1989). Such barns are constructed every year and are situated near the house under a tree to protect the tuber from excessive heat.

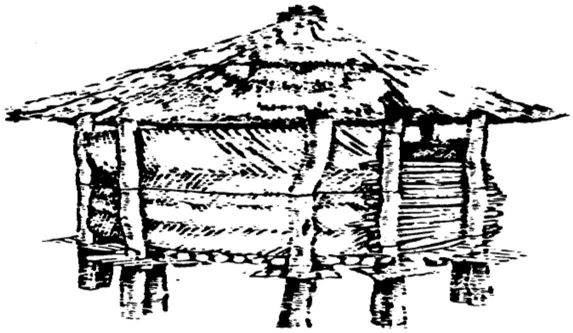

Figure 3: **Yam Houses**

Another yam storage structure found in the North central zones of Nigeria is the yam house (Opara 1999; Wilson 1980). "Yam houses" have thatched roofs and wooden floors, and the walls are sometimes made simply out of bamboo. They are raised well off the ground with rat guards fitted to the pillars. Yam tubers are stacked carefully inside the crib (Figure 3). Yam is also stored underground in trench or clamp silos. In both methods a pit is excavated and lined with straw or similar material (Nwankiti and Makurdi 1989). The tubers are then stored on the layer of straw either horizontally on top of each other or with the tip vertically downwards beside each other. The yams are then covered with straw or similar materials; in some cases a layer of earth is also added.

Modern yam storage

There are several improved yam storage structures which basically involves an improvement on the traditional storage structures already existing with numerous structural problems which marks their ineffectiveness. Traditional yam storage methods such as: delayed harvesting, pit storage, ditches, clamps and especially the yam barn which involves heaping yams on the barn floor makes yams vulnerable to attack by rodents and other mammals. Also, the method which involves tying individual yam tubers to the poles' framework is very tedious and can also restrict ventilation and consequently accentuate any tendency to deterioration. It is therefore, worthy of note that virtually all the improved yam storage methods represent attempts to overcome the shortcomings of the typical traditional storage methods.

i. The Open-Sided Shelves Store

This yam storage structure is similar to the traditional yam barn structure where yam tubers are tied to the framework. However, the design of the open-sided shelves store provides that the yam tubers will be placed in single layers on shelves rather than being tied to the framework.

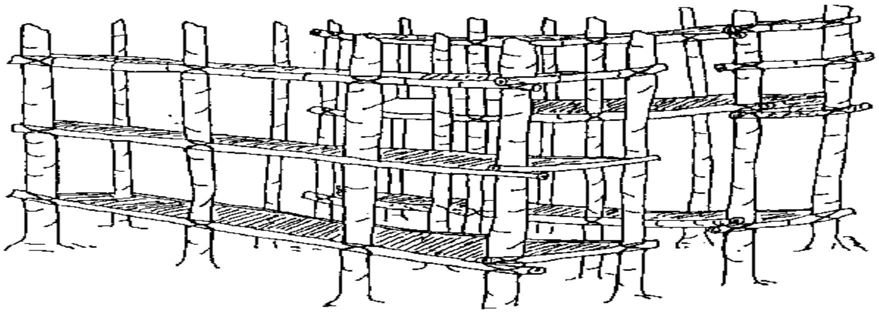

Figure 4: Simple Wooden Shelves for Yam Storage. Source: NISPRI (1982)

The Nigerian Stored Products Research Institute (NSPRI) who designed this yam storage structure opined that the structure ensures simple and easy operation in the storage and allows the stored yams to be handled more carefully so as to avoid the tediousity involved in tying the tubers to the framework and the consequent damage associated with it.

ii. The Ventilated-Pit Store or Ventilated Cellar

FAO (1998) submits that this yam storage structure was designed by the Department of Agricultural Engineering of the University of Nigeria, Nsukka, for the storage of fresh yam tuber. That the structure is a rectangular pit which is 2.9 meter long, 1.3 meter wide and 1.5 meter deep, with a capacity to accommodate 200 yam tubers placed on wooden shelves. According to Ezeike (1995), the pit is covered by a Cupola shaped galvanized sheet metal roof which serves to protect it from sun and rain.

Key: A= Door
B= Grilled openings
C= Chimney

Source: MFCL, GMC and NARI (2004)

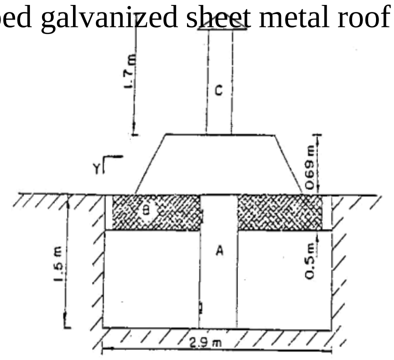

Figure 5: Simple Ventilated Cellar

Temperatures in the pit structure remained constant over the range of 21^{0}C to 24^{0}C, which is lesser than the temperature in the barn. The mean weekly relative humidity of the pit was consistently high and ranged from 83.9% to 93% (FAO (1998)

Weight Losses in Yams Stored Inside the Ventilated Pit Stores and the Yam Barn at Different Stages

Post-Harvest Stage	Weight loss due to respiration % per day	Total weight loss % per day	
		Ventilated Pit	Yam Barn
Harvest	0.08	0.25	0.25
Dormancy	0.02	0.17	0.27

Sprouting	0.07		0.23	0.35

Source: FAO (1998)

iii. The Thatched-roof Pit

This storage structure which is in other words known as the cellar-hut is noted to be similar to ventilated pit store, but with a significant variation which is a thatched roof as showed on figure 6 below.

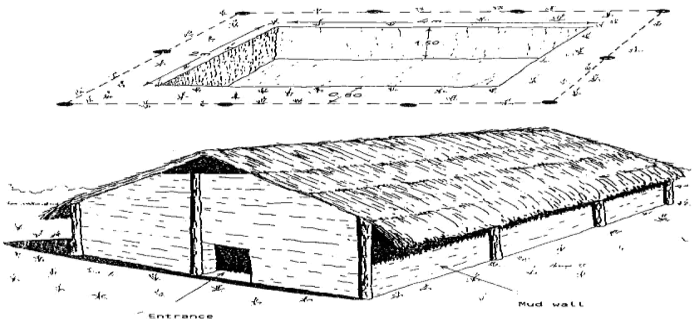

Figure 6: The Thatched-roof Pit or Cellar-hut Storage Structure. Source: MFCL, GMC & NARI (2004)

In regard to the effectiveness of this storage structure, MFCL et al (2004:6) observed that a high relative humidity is established inside the cellar-hut which results in less tuber weight loss.

iv. The Elevated Shed Store

The elevated shed store is also known as raised hut or yam house or crib. MFCL, et al (2004:6) noted that this storage structure can be made from locally available materials such as: wood, bamboo, straw, etc. and can hold about 3tons of yams. That the raised hut should be mounted on poles fitted with anti-rodent shields or guard. That the rodent guards consist of metal sheets that are wrapped around the poles supporting the structure, which its floor should be about 1 meter above the ground, as shown on figure 7 below.

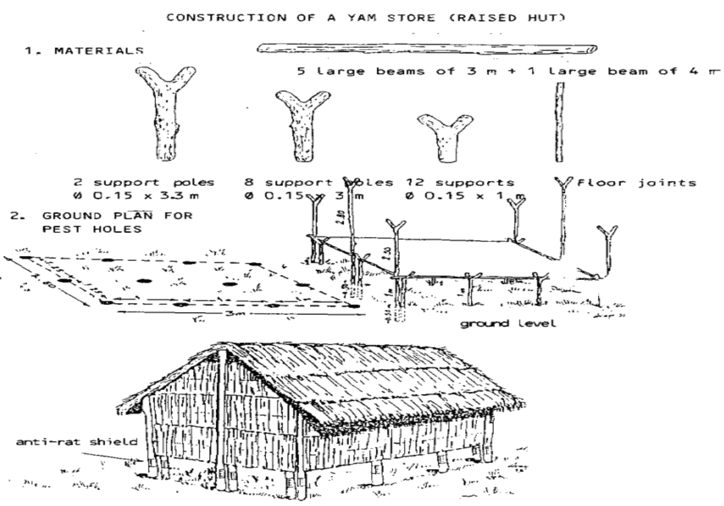

Figure 7 Construction of a Raised hut Storage Structure Source: MFLC, et al (2004)

Again, success has also been recorded in the use of other more advanced yam storage method like refrigeration. FAO (1998) established that refrigerated yam storage at about 15^0C in combination with the use of fungicides has been successful. However, there is no empirical statistics on the extent of the success or effectiveness of the method. The lack of data on refrigerated yam storage could be as a result of the lack of widespread adaptation of the method, to which the FAO have argued that the widespread use of cold storage of yams is not yet feasible because of the high capital cost and the need for a technical support structure. Nevertheless, with the combination of some yam storage application methods like Gamma radiation which has been successfully used to inhibit yam sprouting and reduce weight losses in tubers for up to eight months as shown in the works of Adesuyi (1982) and Demeaux, Babacauh and Vivier (1982), coupled with proper storage management practices, optimal results can always be recorded with the improved storage methods against the traditional yam storage methods.

CONCLUSION

Yam tubers are generally abundant and sold cheaply in the study zone at harvest, but later (especially during the planting season) they become scares and expensive. If yam could be stored without heavy losses, suppliers could become steadier, price would fluctuate less and farmers would be encouraged to grow their yam by being assured of steadier income. The study discovered that lack of finance accounted for the predominance of traditional methods and recommended that government should also help to subsidized modern storage facilities to the tuber farmers

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Effect Of Processing On The Swelling Power And Water Absorption Capacity Of Stored Orange Fleshed Sweet Potato Flour

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ABSTRACT

This study evaluated the effect of different processing methods on the swelling power and water absorption capacity of stored flour processed from Orange fleshed sweet potato variety Umuspo1. The fresh roots were harvested, peeled, washed and divided into 4 equal portions for blanching, boiling, treating with metabisulphite and the last one without treatment. Each of the samples were further divided into 2 equal parts for oven and sun drying and thereafter packaged and stored for 3months. Analysis was carried out on the stored flour samples in interval of 1 month basis till end of storage period. The result obtained showed that there were significant differences (P>0.05) in the parameters of the flour samples evaluated Swelling power and water absorption capacity of the flour samples ranged from 13.27g/ml (Untreated sun dried) - 15.54g/ml (Untreated oven dried) while water absorption capacity ranged from 2.36% (boiled oven dried) -2.75% (untreated oven dried). There were steady decreases in the parameters evaluated across the storage period of 3months.
Key words: Flour, functional properties, sweet potato

INTRODUCTION

Sweet potato (*ipomea batatas Lam*) has been described as a food security crop owing to its appreciable quantity of an organic pigment called b-carotene as well as other nutrients such as vitamins, minerals, protein, dietary fiber and polyphenols (Motasa et al., 2015). Orange-fleshed sweet potato, a variety of sweet potato is a bio- fortified crop developed solely as part of global effort to checkmate vitamin A deficiency (Harvestplus, 2009). Post-harvest losses are minimized by processing sweet potato into flour, an intermediate product. This makes it available all round the season by extending its shelf life and also serve different purposes in food industries where they are used as raw materials in making confectionaries such as bread as well as thickening agent for soups and gravy, there by increasing its utilization(Eleazu and Ironua, 2013). The knowledge of Functional properties of flour are valuable as it gives an insight into its behavior when used in industrial food application. Functional attributes of flour are affected by processing methods (Osundahunsi et al., 2003), drying as well as pretreatment methods (Yadav et al., 2006, Maruf et al., 2010b). Sweet potato flour is usually stored for a period of time however different factors such as the moisture content, processing method and condition of the processing area as well as storage environment affects the storability (Kakichevsky et al., 2000). This study therefore aims at evaluating the effect of processing method on selected functional properties of the stored sweet potato flour.

MATERIALS AND METHOD

Fresh orange fleshed sweet potato variety, UMUSPO 1 (6kg) was harvested from the National Root Crops Research Institute (NRCRI) experimental farm. These roots were washed, peeled, diced (2.5mm) and divided into four portions for processing into flour using three pre-treatment methods: Blanching (5mins at 80 ^{0}C), boiling (till tender) and soaking with 0.5% sodium metabisulphite solution for 10mins. The fourth portion was untreated and was used as the control sample. All the samples were divided into equal parts for oven and sun drying. They were thereafter milled into flour and then packaged for further analysis. The flour samples were packaged in transparent polyethylene bags and stored at ambient temperature (30± 2ºC) (Ukpabi et al., 2014) and were evaluated for swelling power and water absorption capacity.

Swelling Power determination

The methods described by Li and Yeh (2001) was used in the determination of the swelling power of the stored flour samples. Swelling power is a measure of the hydration capacity of starch and is expressed as the weight of centrifuged swollen granules, divided by the weight of the original dry starch used to make the paste. About 2g of the samples was suspended in 10ml of water and incubated in a thermostatically controlled water bath at 95^{0}C in a tarred screw cap tube of 15 ml. the suspension was stirred intermittently over 30 minute's periods to keep the starch granules suspended. After this, the weight of the swollen sediment was determined.

Supernatant liquid (dissolved starch) was poured into a tarred evaporating dish and put in air oven 10 100^0 C for 4 hours.

$$\text{Swelling power} = \frac{W_2\ x\ 100}{W_{dm}\ (100 - Solubility)} \qquad (1)$$

Water absorption capacity determination

The method described by Onwuka (2005) was used in determining the water capacity of the samples. Exactly one gram (1.0g) of each sample was weighed into a graduated 15ml centrifuge tube and 10ml distilled water was added. The flour samples were mixed thoroughly and allowed to stand for 30 minutes at room temperature and centrifuged at 2000-5000rpm for 30 minutes. The volume of free water was then determined (the supernatant was read directly from the graduated centrifuge tube).

Calculation

$$\text{Water absorption capacity} = (V_1 - V_2)\ \text{ml/g} \qquad (2)$$

Where

V_1 = initial volume of water before centrifugation.

V_2 = final volume of water after centrifugation.

RESULTS AND DISCUSSIONS

Table 1: Effect of storage on swelling power (g/ml) of OFSP flour

Sample	Month 0	Month 1	Month 2	Month 3
UOD	15.54 ^{a} ±0.00	15.45 ^{b} ±0.01	15.40 ^{c} ±0.01	15.32 ^{c} ± 0.06
MOD	15.54 ^{a} ±0.01	15.34 ^{b} ±0.01	15.20 ^{c} ±0.02	14.91^{d} ± 0.04
BOD	14.29 ^{a} ± 0.01	14.25 ^{a} ± 0.04	14.22 ^{b} ± 0.04	14.08 ^{c} ± 0.06
BoOD	13.59 ^{a} ± 0.01	13.57 ^{a} ±0.01	13.57 ^{a} ± 0.02	13.54 ^{b} 0.02
USD	13.27 ^{a} ±0.01	13.15 ^{c} ±0.00	13.24 ^{b} ± 0.01	13.12 ^{c}± 0.04
MSD	13.37 ^{a} ±0.04	13.30 ^{b} ± 0.03	13.25 ^{c} ±0.00	13.24 ^{d} ±0.01
BSD	13.50 ^{a} ±0.01	13.49 ^{a} ± 0.01	13.48 ^{a} ±0.00	13.43^{b} ± 0.01
BOSD	13.32 ^{a} ±0.06	13.29 ^{a} ±0.04	13.20 ^{b} ±0.01	13.17^{c}±0.00

The values are means ± Standard Deviation of three determinations. For each variety, means with the same superscript across the row are not significantly different (p<0.05)

UOD = untreated oven dried, MOD = metabisulphite treated oven dried, BOD = Blanched oven dried, BoOD = Boiled oven dried, BSD = Blanched sun dried, BoSD = Boiled sun dried, USD = Untreated sun dried, MSD = Metabisulphite treated sun dried. The effect of storage in the swelling power of the flour samples is represented in Table 1 and the result showed that at 0 month, all the samples had high swelling power ranging from 13.27g/ml in untreated sun-dried sample to 15.54g/ml in untreated oven dried sample at 0 month. There was no significant difference in the swelling power of untreated oven dried sample and metabisulphite treated oven dried sample at 0 month. As storage progressed from 1st to the 2nd month, decreases were observed in the samples except in boiled oven dried and blanched sundried samples which showed no significant difference in the swelling power of these samples from 0-2nd month. At the end of storage period (3 months), it was observed that all the samples had reduced swelling power indicating that storage had a significant effect in swelling power of the flour samples during storage. This is supported by Katekhong and Charoenrein (2012) in his work on rice flour sample as starch granules of stored flour are resistant to swelling when compared to fresh flour samples hence the ability to soak more water and swell up is reduced as storage progressed

Table 2. Effect of storage on water absorption of capacity (%) of OFSP flour

Sample	Month 0	Month 1	Month 2	Month 3
UOD	3.05 ^{a} ±0.07	3.00 ^{b} ±0.00	2.85 ^{c} ±0.07	2.75 ^{d} ± 0.07
MOD	2.95 ^{a} ± 0.07	2.95 ^{a} ± 0.07	2.75 ^{b} ± 0.07	2.70 ^{c} ± 0.00
BOD	2.75 ^{a} ± 0.07	2.65 ^{b} ± 0.07	2.45 ^{c} ± 0.07	2.40 ^{d} ± 0.00
BoOD	2.63 ^{a} ± 0.07	2.60 ^{b} ± 0.00	2.40 ^{c} ± 0.07	2.36 ^{d} ± 0.85
USD	2.90 ^{a} ± 0.00	2.85 ^{b} ± 0.07	2.65 ^{c} ± 0.07	2.51 ^{d} ±0.01

MSD	3.00 ^{a} ± 0.00	2.95 ^{a} ± 0.07	2.85 ^{b} ± 0.07	2.70 ± 0.00
BSD	2.85 ^{a} ± 0.07	2.65 ^{b} ± 0.07	2.60 ^{c} ± 0.00	2.45 ^{d} ± 0.20^{d}
BOSD	2.80 ^{a} ± 0.00	2.65 ^{b} ± 0.00	2.35 ^{d} ± 0.0	2.45 ^{c} ± 0.07

The values are means ± Standard Deviation of three determinations. For each variety, means with the same superscript across the row are not significantly different ($p<0.05$)

Oil absorption capacity of stored flour is shown in Table 2. The values obtained showed that storage caused a significant difference ($p<0.05$) in the water absorption capacities of the flour samples during storage. All the samples showed a steady decrease in their water absorption capacities from 0month – 3rd month however, untreated oven dried sample had the of highest WAC 2.75% while boiled oven dried sample had the least value of 2.36% at the end of storage. Blanched and boiled sun dried flour samples recorded the same WAC at the end of the storage period. Water absorption capacity is used to describe the ability of the flour samples to absorb water and swell as this helps for improved consistency in the food. (Osundahunsi *et al.,* 2003; Malomo *et al.,* 2012). It is also used to describe the degree of interaction of the starch granules of food with water (Ruales *et al.* 1993). Reduction **o**bserved in water absorption capacities of the flour samples at the end of storage period may be due to the increased moisture content values of the flour samples and the corresponding associative force which occurs within the granules of the starch during storage

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Effects of hydrothermal treatments on the proximate and mineral compositions of dried cassava peels

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ABSTRACT

The study was conducted to determine the effects of hydrothermal treatments on the proximate and some mineral compositions of cassava peels. Three dry samples of cassava peels were treated as raw (A), heated in water at 60°C (B) and 80°C (C) respectively, dried and ground into powder. Standard methods of analysis were used to determine the parameters. The results showed the following values for proximate compositions (%) for A, B and C respectively:. There were increase in the concentrations of crude protein from 4.75 in A to 5.48 in C , crude fibres from 2.40 in A to 2.59in C , ash contents from 6.88 in A to 8.10 in C and mineral elements (insert the name and value minerals here) determined as the temperature increased. It could be concluded from the results that generally, the nutritional qualities of the cassava peels increases with the temperature of treatment though they did not meet the standards required for farm animal in some cases

INTRODUCTION

Rearing of animals for domestic and commercial purposes these days usually involves the provision of adequate feedstuffs for the animals andone of such feedstuffs that serveas sources of nutrients for feeding ruminant animals today is cassava peel. According to Anaeto *et al.* (2013), Cassava peels form the bulk of residue from cassava root after post-harvest and processing. It is a good source of energy in ruminant feeding systems, serving either as the main basal diet or as a supplement. The processing of cassava tubers yields cassava peels which is a by-product that is valuable ruminant feeds when properly processed (Aro *et al*.,2010). Cassava (*Manihot esculentus*)is a tuberous root crop belonging to the family *Euphorbiaceae***,** genus *Manihot.* Carbohydrate, protein, vitamins, and minerals are all found in its roots and leaves (Bayata, 2019). Cassava peels derived from *garri* processing are normally discarded as wastes and allowed to rot in the open, thus resulting in health hazards(Antai and Mbongo, 1994). Since these peels could make up to 10% of the wet weight of the roots, they constitute an important potential resource for animal feeds if properly processed by a bio-system (Antai and Mbongo, 1994).

There are reports of different methods being used for the processing cassava peel to improve its nutrient contents. However, there is no record of the use of hydrothermal treatment, at different temperatures, to find out if there will be improvement or otherwise in the nutrient content of cassava peel. This study, therefore, sets out to bridge this gap by using hydrothermal treatment at different temperatures and evaluate the effects of the treatments on proximate and some mineral element compositions of cassava peel and determine if there is improvement or not on nutritional quality of cassava peel.

MATERIALS AND METHODS

Area of the study: The study was carried out at the Research Laboratory of Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria.Igboora is located in derived Savannah Zone of 7°15' North and 3°30'East of the Equator with an average annual rainfall of 1278mm and an annual temperature of 27°C (Akamigbo, 2010).

Sample and sample treatments: Cassava peels were obtained from cassava (*Manihot esculenta)* uprooted (from College Farm of Oyo State College of Agriculture and Technology, Igboora, washed and peeled. The cassava peels were again properly washed with water and air-dried for four weeks. The air-dried cassava peels were divided into three portions (1kg each) to form three treatments used in the study. A portion of the samples was not treated (raw) and served as control while the other two portions were heated in water (hydrothermally treated) at 60°C and 80°C respectively.The hydrothermally treated sample were removed from water and air-dried. Thereafter, the three samples were pulverized using the hammer mill and stored in air tight containers until required for chemical analysis.

Proximate composition analysis: Proximate composition analyses were carried out on the three samples to ascertain the differential composition of the various nutritional components and their concentrations the amount in which they are compose The following nutritional parameters were determined as proximate composition: ash content,moisture content, crude fat, carbohydrate,crude fibre, total protein and mineral composition.The official method of AOAC (2005) was used to determinethe moisture contents, while Tecator Digestion System and Kjeltec Auto 1030 Analyzer (Tecator AB, Sweden) wasused to determine the protein contents. The Soxtec SystemHT method (Tecator Soxtec System HT 1043 Extraction Unit, Tecator AB, Sweden) was used to determine the fatcontents. The AOAC (2005) official method was used to determine the ash contents. The crude fibre contents weredetermined in accordance with AOAC (2005).

The valueof 5.95 was used as protein conversion factor during calculation.Protein yields were thus calculated as follows: The value of 5.95 was used as protein conversion factor during calculation. Protein yields were thus calculated as follows:

$$\text{Yield (\%)} = \frac{\text{weight (g) of PBPI} \times \text{protein content (\%) of PBPI} \times 100}{\text{10 g (weight of DPB)} \times \text{Protein content (\%) of DPB}}$$

The carbohydrate content was determined by difference, after addition of all the percentages of moisture, fat, crude protein, ash, and crude fiber and was subtracted from100%.

Carbohydrate (%)=100 −[protein (%) + Moisture (%) + Ash (%) + Fiber (%) + Fat (%)].This gave the amount of nitrogen-free extract otherwise known as carbohydrate content.

Mineral analysis: The official method of AOAC (2005) was adopted for the mineral analysis of the samples: the samples were previously ash in a furnace for 5 h at 600°C, and then refluxed with 20% hydrochloric acid. The mixture was filtered into a 100 mL standard flask; the filtrate was then made up to the mark with deionized water. Sodium(Na) and potassium (K) levels of the samples were ascertained using a flame emission photometer with NaCl andKCl as standards. All other metals were determined byatomic absorption spectrometry (AAS).

Statistical analysis: All values are presented as the mean ± standard error of two replicate analyses. For multiple comparisons, the data were analyzed by one-way ANOVA followed by Tukey's posthoc test (GraphPad Prism. 5.03, La Jolla, CA). The differences were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

Table 1: Proximate composition of raw and hydrothermally treated cassava peel

Proximate (%)	Raw samples	Hydrothermally treated samples	
		60°C	80°C
Crude protein	4.75±0.00	5.07±0.02	5.48±0.01
Crude fat	2.40±0.00	2.21±0.05	2.59±0.00
Crude fibre	6.88±0.01	7.25±0.00	8.10±0.01
Ash	3.49±0.01	3.61±0.01	3.74±0.02
Moisture contents	10.11±0.01	9.90±0.00	9.80±0.05
Carbohydrates	72.37±0.02	71.96±0.01	70.29±0.01

Data were expressed as mean ± SD.

Table 2: Mineral compositions of raw and hydrothermally treated cassava peel

Mineral element (mg/kg)	Raw sample	Hydrothermally treated Samples		Standard value (Lee, 2009)
		60°C	80°C	
Sodium	0.077±1.06	0.089±0.02	0.097±0.04	0.10
Potassium	0.124±0.01	0.132±0.00	0.143±0.42	0.23
Calcium	0.086±0.02	0.092±0.00	1.021±0.01	0.60
Magnesium	0.103±0.04	0.107±0.01	0.116±0.02	0.04
Phosphorus	0.127±0.01	0.136±0.02	0.147±0.03	0.50
Zinc	5.70±0.04	6.80±0.02	7.80±0.05	
			0.00006	
Copper	2.20±0.02	2.80±0.01	3.60±0.01	
			0.000004	
Chromium	0.19±0.01	0.25±0.00	0.38±0.04	ND

Data were expressed as mean ± SD.
ND = Not determined

Table 1 showed the results for the proximate compositionsof raw and hydrothermally treated cassava peels. Proximate composition is animportant criterion to determine the nutritional values and quality of food (Qayyum *et al*., 2012).The high protein content of sample heated at 60°C and 80°C could be attributed to the heat effects on the samples which increase the composition and availability of protein the sample by inactivating antinutritional factors. It is on record that dietary proteins plays important roles in natural synthesis and maintenance of body tissues, enzymes, and hormones as well as other substances required for healthy functioning (Hayat *et al*. 2014). The crude fibre (cell wall contents) fractions of the raw cassava peels were not as high as the values for the hydrothermally treated samples and the highest crude fibre were obtained at 80°C. This suggested that blanching cassava peel may improve the fibre content and its digestibility thereby promoting its use in livestock production. The higher ash contents of the samples heated at 60°C and 80°Cas compared to the raw sample is also an indication that heat treatment was able to free some antinutrient-bound mineral elements since high ash contents is an indicationthat a sample contains abundant mineral content (Iqbal *et al*., 2012).The lower moisture contents of heat treated samples when compared to that of the raw sample is desirable because high moisture content encourages the growth of bacteria and mould, which could reduce stability and shelf storage capability. The low moisture contents will therefore increase the shelf life of the samples. The low moisture contents may be as a result of enhancement of soluble proteins into the blanching water of the hydrothermally treated samples (Lola, 2009). The higher fat content of the heat treated sample as compared to the raw sample is, however, not desirable The low carbohydrate contents of the heat treated sample could be beneficial to likely diabetic animals with increased serum lipid levels.

Table 2 shows the results of mineral element concentration of raw and hydrothermally treated samples. The results revealed that both raw and hydrothermally treated cassava peels contained macro/micro minerals in varying amounts as evidenced in the concentrations obtained. The values obtained for all the treatments were lower than the standards for farm animals quoted by Lee (2009), there were improvements in the quantities of the minerals when the samples were blanched at 80^{o}C (Table 2) Minerals are good for maintaining proper body function and good health. Deficiency of minerals leads to increased susceptibility to infectious diseases due to weakened immune systems. Kermanshah *et al.* (2003) and Mlitan(2014) reported that ‘’iron is an essential trace element for haemoglobin formation, normal functioning of central nervous system and in the oxidation of carbohydrates protein and fats’’. It also plays an active role in oxygen transfer in the body and low iron content causes gastrointestinal infection, nose bleeding myocardial infection. According to Longo and Camaschella (2015) iron deficiency results in anaemic condition when there is decreased level of red blood cells as a result of significant reduction of iron content in the animal body. The appreciable copper content of the heat treated sample at 80^{0}C implies that it is a good source of copper. Copper plays a fundamental role in cellular metabolism as it serves as cofactors for various important enzymes to function properly as well as in the formation of hemoglobin, myelin, and melanin, where it has been identified toplay an essential role. Added to this, copper may also act as an antioxidant or a prooxidant. Zinc is an essential trace element which plays an important role in various cell processes including normal growth, brain development, behavioural response, bone formation and wound healing (Ullah *et al*., 2012). A deficiency in zinc results increased rate of diarrhoea, delayed wound healing process, impaired immune function and some psychological disorders (Lonneral,2000). Calcium is the major component of bone and assists in teeth developments, essential for blood coagulation and the integrity of intracellular cement substances (Ullah *et al*., 2012). Deficiency of calcium also known as hypocalcaemia leads to diseases such as osteoporosis and osteopenia. The macro metals concentrations obtained in this study for raw and hydrothermally treated peel were relatively low (Prasad, 2013). It is on record that calcium also enhances the effective use of iron in the system (Adeyeye, 2013). Iron is also an essential mineral element present in in adequate amount in sample treated 80°C, but this element is required for a number of biological functions, including proper functioning of the immune system, electron transfer reactions, gene regulation,cell growth and differentiation as well as binding and transport of oxygen (Siddiqui *et al*., 2014). (Piero *et al*. 2012; Akhuemokhan *et* *al*. 2013; Khan and Awan, 2014). The contents of zinc present in the samples treated at 80°C and 60ºC were higher than that of the standard (Table 2)

CONCLUSION

In conclusion, this study has shown that hydrothermal treatments had significant effect in the enhancement of nutritional components and mineral elements of cassava peels. Hydrothermal treatment at 80°C was found, in this study, to be the most effective method in the enhancement of nutritional components and mineral elements of cassava peels. It is hereby recommended that cassava peel, when hydrothermally treated,can be effectively incorporated in livestock feed as energy and mineral sources. There is the need for future research in the same manner to ascertain whether at temperature above 80°C the nutritional and mineral elements concentration will be improved upon.

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Effect of varietal differences and Pretreatment methods on nutritional content of cocoyam flour

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ABSTRACT

Every crops is unique in its way in that it comes with a different nutrient content and the nutrients are altered based on the processing method adopted during preparation. Two varieties of Xanthosoma sagittifolium, ede ocha (NXs001 (white flesh) and ede uhie (NXs002 (purple flesh), were purchased from Ndi oru market Umudike, Abia State. Two different pretreatment methods where one portion was blanched in hot water at 95^{O}C for 5 min (NXs 001B) and the other portion was soaked in 0.3 % sodium metabisulphite solution for 30 min (NXs 001S). The same was done for xanthosoma NXs 002 (ede uhie), thus having three from ede ocha. Also same pretreatment was done for ehe uhie to get NXs 002C, (Control sample with no treatment), NXs 002B (Blanched sample) and NXs 002S (treated with 0.3% sodium metabisulphate) . They were processed into six flour samples. The resultant flour samples were used for proximate and phytochemical determination. The result generated indicated that the treatment method caused a significant different in the proximate composition with an increase in the moisture, protein. Fiber, ash and a decrease in the carbohydrate content for both ede ofe and ede uhie .The treatment method brought a reduction in the phytochemical content for all samples investigated. The study suggest that the adoption of blanching and sodium metabisulphate as a method of processing flour is recommended to reduce the anti-nutrients

INTRODUCTION

Cocoyam (*Colocasia esculenta and Xanthosoma sagittifolium)* is an herbaceous perennial that belong to the family *Araceae* and the edible root is the main purpose of growing coco yam. The corms and cornels are edible starch (Rashmi *et al*., 2018). Africa is the largest producer of cocoyam with Nigeria and Ghana taking the lead. Over 30-40 species of cocoyams have been identified but only few of about 5 to 6 species are edible because they produce edible parts (Obongekpe 2020). Two genera of cocoyam are widely cultivated in Africa-which are the taro (*Colocasia esculenta*) and tannia (*Xanthosoma sagittifolium*). The nutritional values of a crop plays a vital role in considering it as a food source. Several factors influence the nutritional content of food. These include the genetic make-up of the plant, agronomic practices adopted during planting, maturity at harvest, storage conditions and method utilized for processing (Adesina *et al*., 2020.) The presence of anti-nutrients in coco yam has been a source of major concern to human health (Ukom and Okorue 2018).

Processing method such as cooking heating are known to partially removed, reduced or completely inactivate most anti nutrients find in coco yam (Suhag et *al*., 2021). Processing (cooking) can be both beneficial and detrimental to nutrient composition of foods. This is true because the processing techniques adopted may decrease the food quality of the original crops (Kumar. and Kalita 2017). It may enhance the nutritional quality of the food by destroying some of the harmful anti- nutrient available thereby, improving the digestibility of protein and starch (Ertop, and Bektaş 2018).Objectives of the study were the evaluation of effect of varietal differences and treatment method on the proximate content and the phytochemical composition of *xanthosoma sagittifolium* flour

MATERIALS AND METHODS

Two varieties of *Xanthosoma sagittifolium*, NXs 001 (ede ocha (white flesh) and NXs 002 (ede Uhie (purple flesh), were purchased from Ndi oru market Umudike, Abia state. The samples NXs 001 (ede ocha) and NXs 002 (ede uhie) were sorted, peeled, washed and cut into 2 mm slices and each was divided into 3 equal parts of 500 grams to be processed using 2 different pretreatments and the first portion serve as control. For *xanthosoma* NXs 001 (ede ocha) the first portion served as Control (NXs 001C), then pretreatments were done in two parts. One was blanched in hot water at $95^{O}C$ for 5 min (NXs 001B) and the other portion was soaked in 0.3 % sodium metabisulphite solution for 30 min (NXs 001S). The same was done for *xanthosom*a NXs 002 (ede uhie), thus having three samples; NXs 002C, (Control sample with no treatment), NXs 002B (Blanched sample) and NXs 002S (treated with 0.3% sodium metabisulphate). The samples were later dried at 70°C for 6 hrs and milled in attrition mill, sieved and stored in an air tight container for further use. Anti-nutritional factors and proximate composition were determined with the method as described by AOAC (2012).

Data generated were subjected to statistical package IBM SPSS Programme version 22. Results were expressed as mean ± standard error of mean (SEM). One-way analysis of variance (ANOVA) with Duncan post hoc test were used to evaluate the statistical difference between the different groups. The graph was done with graph pad prism 5.

RESULT AND DISCUSSIONS

The results in Table 1 showed that moisture content, protein, fiber, fat, ash and carbohydrate which ranged from 6.18% to 8.70%, 4.90% to 6.42%, 3.10% to 5.00%, 0.22% to 1.13%, 3.80% to 7.18% and 74.67% to 81.73% respectively. The result showed that the treatment methods improved the proximate composition. The reduction as seen in the blanched samples can be attributed to denaturation of the protein of the flour during blanching and diminution of the protein solubility of the cocoyam flour due to the heat treatment (Liu, *et al*., 2019). The fat content ranged from 0.59 to 1.13 and 0.17 to 0.36 for the white and purple *xanthosoma.* The result showed that treatment by blanching and sodium metabisulphate caused an increase in the fat content of the flour samples. The values were relatively comparable with the average crude fat contents (0.22-0.85%) of cocoyam as reported by Wada et al. (2019). Pretreatment of the samples brought an increase in the parameters tested, however, pretreatment brought about a progressive decrease in the carbohydrate content of treated samples. This is in line with the finding of Ndagui *et al.*, 2014. The moisture content is within the acceptable limit, thereby making the samples storage stable, which will encourage a longer shelf life

Table: 1. Effect of Treatment on the Proximate of *Xanthosoma* species

Sample	Moisture%	Protein%	Fiber%	Fat%	Ash%	CHO%
						White xanthosoma
NXs 001S	7.42±0.06^{a}	5.34±0.01^{a}	4.20±0.00^{a}	1.13±0.04^{a}	4.78±0.03^{a}	77.13±0.00^{c}
NXs 001B	6.81±0.01^{b}	4.90±0.03^{b}	3.76±0.01^{b}	0.90±0.02^{b}	4.33±0.03^{b}	79.30±0.00^{b}
NXs 001C	6.18±0.04^{c}	4.60±0.08^{c}	3.10±0.03^{c}	0.59±0.02^{c}	3.80±0.00^{c}	81.73±0.00^{a}
						Purple xanthosoma
NXs 002S	7.53±0.04^{c}	6.43±0.03^{a}	3.83±0.04^{c}	0.36±0.01^{a}	7.18±0.04^{a}	74.67±0.00^{a}
NXs 002B	8.11±0.01^{b}	5.26±0.08^{b}	4.64±0.04^{b}	0.22±0.00^{b}	6.73±0.04^{b}	75.04±0.00^{b}
NXs 002C	8.70±0.01^{a}	4.90±0.14^{c}	5.00±0.00^{a}	0.17±0.01^{c}	4.92±0.04^{c}	76.31±0.00^{c}

Values are mean± SD of 3 replications .Means within a column with the same superscripts were not significant difference (P>0.05). Key: NXs 001C (ede ocha), NXs 001B (ede ocha blanched), NXs 001S (ede ocha treated with sodium metabisulphate), NXs 002C (ede uhie control), NXs 002B (ede uhie blanched), NXs 002S (ede uhie treated with sodium metabisulphate

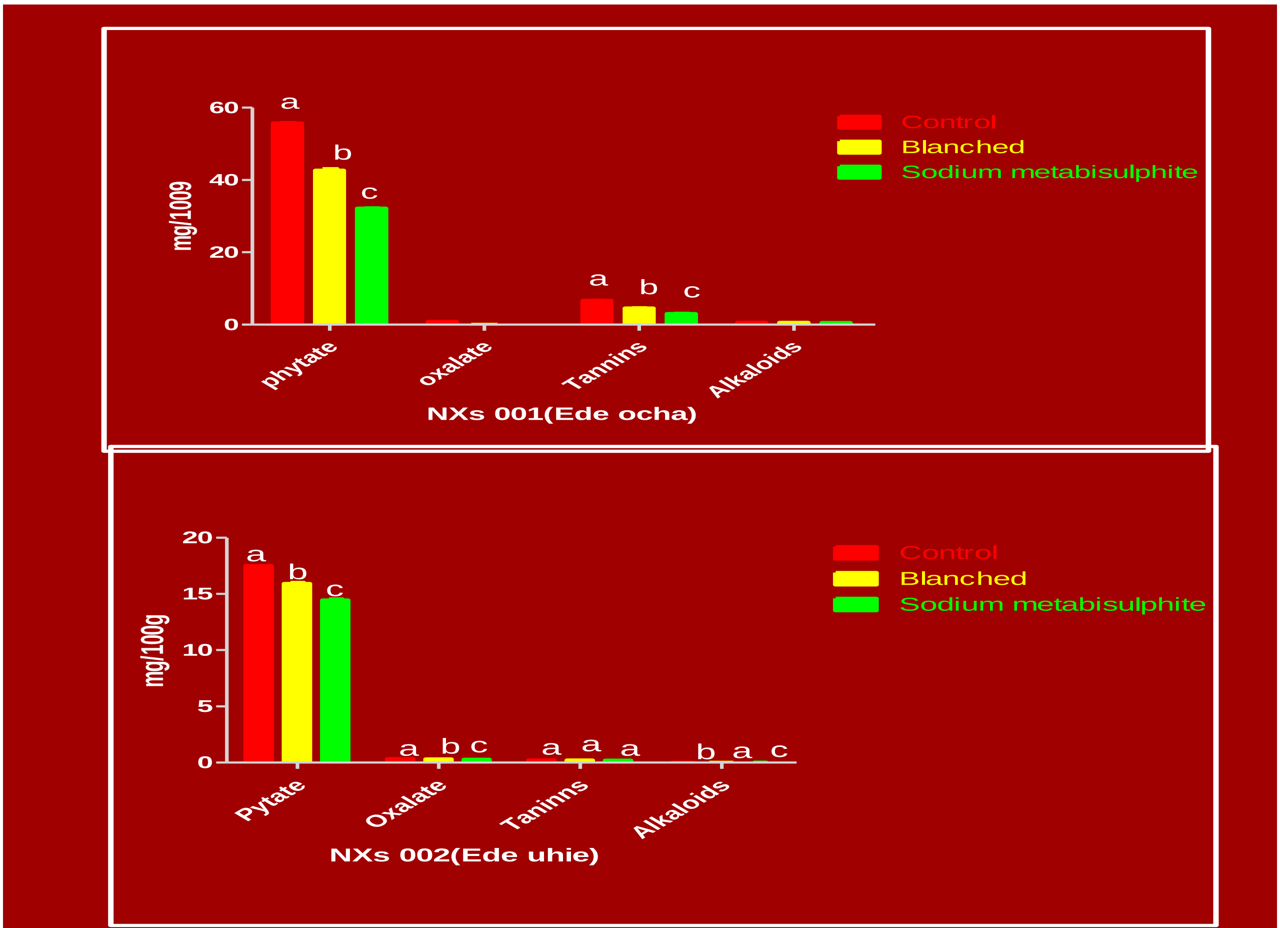

Fig. 1 Effect of variety and methods of treatment on phytochemicals

Fig. 1 showed the phytate, tannins and the alkaloid content of NXs001 ede ocha which recorded high values than the ede uhie NXs002, which ranged from 32.19 to 55.76, 3.04 to 6.75, 0.55 to 0.69 for ede ocha and 14.45 to 17. 52, 2.04 to 2, 48 and .27 to 0.42 respectively. There values varied significantly. Both treatment method caused a reduction in the anti-nutrient investigated. Phytate content is high in the ede ocha and ede uhie when compared with the other anti-nutritional factor investigated. This variation can be attributed to the varietal differences as reported by Calle *et al*. (2021) Phytate phosphorous is unavailable to human, but its presence lowers the availability of many other dietary minerals such as iron and zinc

CONCLUSION

Based on the results generated from this study, it is therefore concluded that subjecting different *xanthosoma* species (NXs 001 and NXs 002) to blanching and sodium metabisulphite as pretreatment methods have significantly changed and improved the nutritional parameters investigated as evidenced in the results generated

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Pro – Vitamin A Cassava: Processing Produce into Products for Nutrition and Health in Nigeria.

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ABSTRACT
Agricultural sector is a strong driver of the Nigerian economy. It employs about 70% of the nation's labour force and has the capacity to alleviate poverty, improve nutrition, health and ensure food security. Investment in agricultural sector enhances economic growth of a country which brings about food security. This paper reviewed Pro-vitamin A cassava: processing produce into products for nutrition and health in Nigeria. The methodology adopted for this study was entirely theoretical; hence there was no indication of quantitative analysis or data. The study found out that Nigeria is one of the countries in the world with serious micronutrient malnutrition problems, and also has the highest number of stunted children in sub-Saharan African. Hence processing pro-vitamin A cassava produce into products like garri, fufu, abacha, cassava bread, cake and chips will reduce the level of malnutrition and stuntedness, thus improving nutritional and health status of her citizen. The paper recommended that the extension linkage with research should be strengthened so as to facilitate the spread of improved cultivars and management practices to farmers. The involvement of more cooperative societies in the multiplication and sales of stems should be encouraged. Also effective integration of information and supply of various inputs is highly recommended.

Keywords: Pro-vitamin A cassava, Processing, Produce, Products, Nutrition and Health

INTRODUCTION
There are many challenges confronting the world, but hunger and malnutrition are two major food issues confronting policy makers and governments due to their link to food insecurity and health (International Institute for Tropical Agriculture (IITA), 2009; Saad, 2009; Anugwa and Agwu, 2019).
Food must be acceptable, affordable, and available to consumers, and consumers must have the resources, knowledge, and correct mindset to purchase and consume these foods (Ogbonnaya, Oteh and Agwu, 2020).

Regrettably, Nigeria is one of the countries in the world with serious micronutrient malnutrition issues leading to major public health especially among vulnerable groups of young children and pregnant women.(Agwu, 2011). In Nigeria, more than 14 million people representing 8.5% of the population are undernourished, based on a 2014 report of the National Health Component of the National Strategic plan Action for nutrition (2014 – 2019). In addition Nigeria has the highest number of stunted children, estimated at 10million in Africa; 37% of these children under the age of five are stunted, 29% are under weight and 18% are wasted (Agwu, 2011, Nwajiuba, 2013). At the global level approximately 250,000 to 500,000 malnourished children in the developing world go blind each year from a deficiency of vitamin A, half of whom die within a year of becoming blind (Adesina, 2011).

The prevalence of night blindness due to vitamin A deficiency is also high among pregnant women in many developing countries. Vitamin A deficiency also contributes to maternal mortality and other outcomes in pregnancy and lactation (Adesina, 2011). Stunting rates are highest in Asia and sub-Saharan Africa. Once established, stunting and its effects typically become permanent. Stunted children may never regain the height lost and most will never gain the corresponding weight. And when the window of early childhood is closed, the associated cognitive damage is often irreversible. UNICEF reports show that 43% of under five children in Nigeria are stunted. This is high when compared to 39% for all developing countries. (Adesina, 2011).

Annually, Nigeria loses over US$1.5billion in GDP to vitamin and mineral deficiencies as many staple foods are low in essential micronutrients (Adesina 2011). These challenges arise as a result of a combination of poor awareness of dietary requirements, feeding practices, and high levels of poverty (Agwu, 2011; Nwajiuba, 2013).

Poor diet is an important factor of vitamin-A deficiency in Nigeria, where rural dwellers consume mostly local staple food crops with relatively low micronutrients, with cassava constituting a major staple in Africa and specifically in Nigeria. Cassava production in Africa is the largest in the world, representing about 54% of global cassava production, while based on country production; Nigeria is the largest cassava producer (Wossen et al., 2017). Significant proportion of vulnerable groups such as rural women of child-bearing age and children whose diets consist mostly of cassava (and cassava by-products) are potentially at risk of vitamin-A deficiency, leading to efforts being intensified to develop and distribute vitamin-A-enriched cassava varieties across Nigeria through a process known as bio-fortification (De Moura et al., 2015).Bio-fortification is an innovation commonly in use now aimed at improving the diet quality of nutritional vulnerable groups, such as children and women. It is recommended where complementary foods do not provide enough essential nutrients(De Moura et al., 2015)..

Cassava and Pro – Vitamin A Cassava in Nigeria

Cassava (*Manihot esculenta*) is one of the staple crops cultivated by both small and large scale farmers in Nigeria and is of strategic importance to the economy of the country. Nigeria is the highest producer of cassava in the world with an estimated annual production of 59,485,947 metric tons (FAO, 2018). The importance of cassava to the livelihoods of many millions of the poor people has made the crop a target for intervention (Agunannah, 2021). The potential of the crop is numerous because it offers the cheap source of food calories and the highest yield per unit area. Cassava has multiple roles as famine reserve, food and cash crop, industrial raw material and livestock feed (Osipira-Patino and Ezedinma, 2015). Across the country, cassava production has undergone a tremendous increase for different reasons, specifically due to introduction of high yielding and disease-resistant varieties, early maturing ones, among other factors (Sanni, Onadipe, Ilona-P, Mussagy, Abssa, and Dixon, 2009). Unfortunately, the conventional white fleshed cassava is not rich in the micronutrient pro-vitamin A to address the double burden of malnutrition, despite the fact that it is a choice food among more than half a billion people around the world and serves over 200 million in Africa; second to maize in its calorie contribution (Talsnia, et al., 2016; FAO, 2011). Cassava has a comparative advantage over other staples and attracts poor resource farmers who constitute the bulk of supplies (Moon et al, 2004; Bamidele et al., 2008) hence the need for biofortification improvement. Biofortification is the practice of deliberately increasing the content of an essential micronutrient (vitamins, minerals including trace elements) in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health, through agronomic practices, conventional plant breeding or modern biotechnology (WHO, 2019).

Biofortification is considered to be sustainable because it requires a onetime investment that further allows farmers to continuously grow the micro-nutrient rich planting material for years to come, at no more cost than the regular crop would cost. Biofortification of staple foods such as cassava, rice, beans, wheat, maize and sweet potato indirectly target low-income households who cannot afford a more diverse diet and who live in rural areas where supplementation programmes cannot reach or cannot afford fortified products (Huffman and Mccluskey, 2014; Agunannah, 2021). According to Randall and Sanjur (1981) biofortified yellow cassava contains vitamin A and results in public health gains. Today, bio-fortification provides one of the best ways to achieve improvements in nutrition.

Crop breeders at the National Root Crops Research Institute (NRCRI) in collaboration with International Institute of Tropical Agriculture (IITA) and the International Centre for Tropical Agriculture (CIAT) under the funding from Harvest Plus Programme have worked assiduously to develop cassava varieties that serve as sources of vitamin A. These pro-vitamin A or beta carotene varieties of cassava would go a long way in correcting the deficiency of this nutrient in diets, particularly those of the poor and the vulnerable at the individual and household levels respectively. Presently, it is estimated that over one million Nigerian farm households are growing 'yellow' cassava varieties, which contain significant amounts of pro-vitamin A even after processing. Yellow cassava now represents an additional source of vitamin A in Nigeria diets. (Ilona and Bouis, 2017).

Several varieties of biofortified pro-vitamin-A cassava varieties exist in Nigeria. These include UMUCASS (36, 37, 38, 42, and 43 varieties), NR 0220, TMS 1371, TMS 0593, and TMS 0539 (Ayinde, 2016; Eyinla et al., 2019).

Currently, the newly introduced varieties of pro vitamin A cassava known as UMUCASS 44, UMUCASS 45 and UMUCASS 46 have a pro vitamin A content that averages 10 parts per million (PPM) based on fresh roots. This set of pro vitamin A cassava varieties have increased beta-carotene levels as well as matching agronomic characteristics as an incentive for better farmer adoption and also help to improve cassava products such as *garri, fufu, high quality cassava flour, cassava bread and starch* (IITA, 2014). Bio-fortification can reduce the prevalence of Vitamin-A deficiency, given prominent role of cassava in the diets of rural households in Nigeria (Oparinde et al., 2016; Garg et al., 2018).

PROCESSING PRODUCE INTO PRODUCTS

A well-known Economist, Professor Felix Nweke wrote a book titled "Cassava: Africa's best held secret". He clearly showed that cassava is no longer a subsistence crop, but a commercial crop. A crop that allows you to make *starch, high quality cassava flour, dried chips for exports, livestock feed and ethanol*, is not a poor man's crop but a rich man's crop.. The interest in

cassava is because it is a choice food among Nigerian`s and is important to people's livelihood, with comparative advantages for cultivation than other crops. But producing more food is not enough, we must also ensure that there is enhanced food nutrition and health.
Paul Ilona of Harvest Plus, once said that given the importance of cassava in Nigeria, pro vitamin A cassava can provide more vitamin A in the diets of over 70 million Nigerians and continue to reduce vitamin A deficiency which is widespread in the country (Vanguard Newspaper, 19th. March 2022).
Therefore, processing cassava produce to products will enable us create new markets for cassava and enhance the nutritional content of processed cassava products through the;
Production of high quality pro-vitamin A cassava garri, fufu, lafun, abacha and tapioca, which is rich in vitamin A and low in carbohydrate content using traditional processing methods. Hence serves as excellent meal for the diabetic. Also,pro-vitamin A cassava produce can be processed into high quality pro-vitamin cassava flour to be used in replacing some of the wheat flour being imported to produce bread. Presently we have cassava bread sold in our super markets. Former President Dr. Ebele Goodluck Jonathan, once said that we must eat what we produce and produce what we eat. If we produce enough vitamin A rich cassava flour, the country can be saving over N250Billion naira annually used in wheat flour importation (Adesina, 2011). With the development of the Pro-Vitamin A cassava, the nutritional quality of the cassava bread in Nigeria will be substantially improved. So while you eat cassava bread, you will get more vitamins, reduce child malnutrition, reduce blindness, enhance the cognitive skills of our children, and reduce infant mortality. So, as you choose pro vitamin A cassava bread, you are choosing improved health and nutrition. Thus, effort should be geared towards including pro-vitamin A cassava in the processing of high quality cassava flour. Other products are; high quality fructose cassava syrup that can be used to replace sugar, high quality cassava cake and dried cassava chips, cassava starch, ethanol and the conversion of cassava peels considered as waste into some livestock feed.

.CASSAVA VALUE CHAIN SPECTRUM

Value chain refers to a chain of activities where products pass through in sequence and at each activity the products gain value. It is the whole spectrum of operations from production to consumption.
The Agricultural Transformation Action Plan (ATA), has as its goal the addition of 20million MT of food to the domestic supply. At the same time, it focuses on agriculture as a business, not a development programme, it focuses on developing agricultural values that can allow farmers to make money from what they produce, through greater value addition (Adesina, 2011).
Also, the Anchor Borrowers Programme launched in November, 2015 by President Mohammed Buhari,is capable of boosting agricultural production through private sector investment in the agricultural value chain which will help in attaining the county's price stability goals, while reducing its dependence on imported food items.
Cassava is one of most important crop for Nigerian farmers and is mostly widely cultivated crops that provide food and income to over 30 million farmers, large numbers of processors and traders (Daniel, Udah, Elechi, Oriuwa, Tijam, Grand Sanni, 2011). Hence, cassava crop will play a significant role in the agricultural production, income generation and employment creation in Nigeria, if it's potentials are properly harnessed. The implication of this is that cassava value-chains are essential for economic development and employment generation, which could at the same time foster revolution in the agricultural sectors as well as encouraging in the growth of Nigerian economy.

The key actors in the cassava value chain spectrum can help to generate income, achieve job creation and contribute to food security. The key actors or collaborators in the cassava value chain are:

Producers (cultivator, planters/farmers): Cassava production in Nigeria is carried out mostly by small holder farmers. There are also a few medium and large-scale producers of cassava in the country (Udemezue, Chinaka, and Okoye , 2019). Transporters are also part of value chain spectrum ***w****hose primary assignment is to move the bulky cassava tuber and stems to where it is needed. Other actors are; Processors, who turn the primary produce into finished product, Agricultural Equipment manufacturers, they are manufacturers of processing equipment used in production, and Marketers, whose function is to make the products gets to the final consumers through the process of buying and selling.*

CONCLUSION:

In terms of nutritional value, cassava is a great source of energy due to its high carbohydrate content; however, it has low levels of fat, protein and micronutrients that are essential for normal growth, eyesight and cognitive development. The opportunities of value addition in farm produce has the potential to not only address the issues of nutrition but also the health status of her citizen Hence, the study reviewed pro-vitamin A cassava; processing produce into products for nutrition and health in Nigeria. The reviewer found out that Nigeria is one of the countries in the world with serious micronutrient malnutrition problems, and also has the highest number of stunted children in sub-Saharan African. Thus, processing pro-vitamin A cassava produce into products like garri, fufu, abacha, cassava bread, cake and chips will reduce the level of malnutrition and stuntedness, thus improving nutritional and health status of her citizen. Hence Pro-vitamin A cassava will be a game changer, if it is adequately advertised and financed. Therefore, It is crucial that accelerated efforts and policy measures should be adopted to improve health and nutrition of vulnerable groups, especially women, infants and children, through nutritional supplementation, diversity of diets and bio-fortification. Awareness creation via improved communication networks is important to provide overwhelming product acceptance, adoption and consumption of bio-fortified cassava.

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Assessment of food quality of some selected ready-to-eat foods sold in open and super-markets in kano, nigeria.

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ABSTRACT

Concern for food quality and safety remains imperative to human and national development. This concern is in consonance with postharvest handlings of food crops either in the manners of processing or storage. The study investigated the quality of some common Ready-to-eat (RTE) foods such as roasted groundnuts, smoke-dried fishes and cassava grit ('Garri') collected from open and super-markets in Kano state. They were evaluated for total aflatoxin, polycyclic hydrocarbons and hydrogen cyanide respectively using HPLC, GC-MS and spectrophotometry methods accordingly. Data obtained for each analysis were subjected to statistical tests where mean differences were compared at 5% probability level. There was significant difference ($p<0.05$) between total aflatoxin level of groundnuts from different markets. Total aflatoxin (AF_{Total}) ranged between 39.53 to 104.92 µg/kg in the open markets while those from super-markets ranged between 11.93 to 53.02 µg/kg. while AFB1 accounted for 91% of each total values, the mean concentration levels of AF_{Total} from the open markets samples exceeded the EU (4 µg/kg) and the codex (15 µg/kg) standards, whereas 75% samples from super markets were within the tolerance limit (4 to 15 µg/kg. From among the twenty- four frequently mentioned PAHs as recommended by European Union and the US- Environmental protection Agency, Benzo[a] pyrene had the highest value of 26.28 µg/kg and 20.19 µg/kg only in the BT-1 and SH-1 samples respectively. Despite fewer number of PAHs detected in BT-1, the Σ PAHs was highest (204.42 µg/kg). There was significant difference ($p<0.05$) in PAHs of smoke-dried fishes from both markets except for BT-1 and BT-2 markets. The level of cyanide contents of 'Garri' ranged from 0.0428 to 0.0811mgHCN/10g an equivalent of 4.28 to 8.11ppm. The cyanide contents of all 'Garri samples were relatively low compared to the ≥10ppm LC_{50} of the WHO limit. Based on these findings, there is a need for periodic surveillance of food, capacity development for processors and marketers on improved handling, processing methods in reducing incidence of food poisoning among consumers.

Keywords: Ready-to-eat, food safety, Markets, smoked fish, groundnuts, Garri.

INTRODUCTION

Ready-to-eat (RTE) foods are a group of food products intended by the producer or the manufacturer for direct human consumption without the need for cooking or other processing effective to eliminate or reduce to an acceptable level micro-organisms of concern (Regulation (EC) No. 2073/2005). They are typically pre-cleaned, precooked, mostly packaged and ready for consumption without previous preparation or cooking (Huang, 2012). They could be traditionally or industrially processed, packaged, or unpackaged and are usually considered to comprise, mainly, the publicly vended foods consumed immediately or later (Cerna-Cortes *et al.*, 2015). Generally, most RTEs are adopted and accepted as part of the cuisine of the people, thus giving them an identity and heritage, which are often passed across generations (Kraig & Taylor, 2013). For example, 'Kulikuli', smoked fish, roasted groundnuts, 'suya', 'kilishi' etc are some of the common RTEs delicacies in Nigeria.

World Health Organisation, 2010 reported that that many RTE vendors either in the open or supermarkets in low and middle-income countries often lack knowledge about good hygiene practices, which may predispose the foods to microbial contamination. The condition is further complicated by the practice of vending RTEs in outdoor environments. Therefore, the foods are exposed to air, aerosols, microbes, insects, and rodents, which serve as sources of food contaminants, jeopardizing the essence of food safety. Furthermore, the inherent nutrients (lipids, protein etc) are oxidized when exposed or not packaged appropriately which affects the quality and shelf life of RTEs.

Common non-microbial-related RTE contaminants include heavy metals, pesticide residues, polyaromatic hydrocarbons. On the other hand, incessant daily exposure to single or fusions of these food contaminants via consumption of contaminated RTEs could lead to a surfeit of adverse health effects. Noticeable effects may range from mild to recurrent nausea, vomiting, and diarrhea (Ceuppens *et al.*, 2011) to severe complications such as cancers, neural tube defects, and even human fatalities (Gibb *et al.*, 2015). Thus, improperly prepared RTEs in low- and middle-income countries, where regulations and monitoring for compliance are grossly inadequate, may constitute a huge risk to public health. In a world of accelerating change, the need for food to be safe remains a constant. Ready access to safe and nutritious food is a basic human right. Yet every year around the world, over 420 000 people die and some 600 million people – almost one in ten – fall ill after eating contaminated food. In fact, foodborne hazards are known to cause over 200 acute and chronic diseases from digestive tract infections to cancer (FAO, 2019). Globally, there is a subjective believe/myth that food vended in supermarkets are free from food borne pathogens and are of high nutritional quality but a lot of research work has debunked the myth and further work is being carried out. In order to contribute to the address of food safety in Nigeria, this research has decided to assess the quality and safe levels of dried and RTE foods like smoked fish, groundnut and cassava grit commonly known as '*garri*' sold in both open and supermarkets in Kano city, Nigeria

MATERIALS AND METHODS

Sample Collection and Handling

One kilogram (1kg) sample each of *garri*, groundnut and smoke-dried fish samples were purchased in triplicates from two open markets and two super markets in Kano State and brought to the food laboratory. One hundred gram (100g) each representative sample was measured, pulverized and packaged in zip-lock bags and ready for individual chemical analysis of total aflatoxin, polycyclic aromatic hydrocarbons and hydrogen cyanide contamination levels.

Determination of Total Aflatoxin Contamination

Total aflatoxin was determined according to Official Methods of Analysis (2000) of the AOAC Method 991.31 with slight modification

Determination of Polycyclic Aromatic Hydrocarbon

Five (5g) of each blended fish sample was spiked with d-PAHs and extracted with mixed solvents of 150ml hexane: dichloromethane (1:1) using soxhlet extraction apparatus for 10hours. The solvent was reduced to 1ml using rotary evaporator and nitrogen gas while the extract was passed through a clean-up column filled with 100-150 mesh silica gel followed by 1g of aluminium oxide and anhydrous sodium sulfate. The column was washed with 10ml of hexane and the PAHs were collected by eluting with 8ml of hexane and 5ml of dichloromethane. Thereafter, the extracts were concentrated to 1ml under nitrogen gas flow at ambient temperature. The solution was injected to GC/MS for PAHs analysis. Quantification of individual PAHs was done based on known concentrations of 24 PAHs standard calibrations.

***GC-MS Analysis Conditions*:** GC-MS analysis was carried out on GCMS-QP2010 PLUS SHIMADZU. The column used was Perkin Elmer Elite - 5 capillary column measuring 30m × 0.25mm with a film thickness of 0.25mm composed of 95% Dimethyl polysiloxane. The carrier gas used was Helium at a flow rate of 0.5ml/min. 1µl sample injection volume was utilized. The inlet temperature was maintained as 250°C. The oven temperature was programmed initially at 80°C for 4 min, then raised to 280°C at a rate of 20°C/ minute and maintained at this for 8min. Total run time was 35 min. The MS transfer line was maintained at a temperature of 200°C. The source temperature was maintained at 280°c. Mass spectra were collected by electron impact ionization at 70eV and data was evaluated using total ion count (TIC) for compound identification and quantification. The spectra of the components were compared with the database of spectrum of known components stored in the GC-MS library.

Determination of Hydrogen Cyanide Content

The cyanide content of '*Garri* samples were determined according to alkaline picrate method with modifications according to Williams and Edwards (1980). The cyanide content of each sample was extrapolated from the standard curve of potassium cyanide as shown in Figure 1.

Data Analysis

Data obtained from each analysis were analyzed using the t-test of SPSS 16.0 version 2007 at 95% confidence level ($p < 0.05$) to compare means.

The total aflatoxin contamination levels in the ready-to-eat groundnut sampled from open and super-markets of Kano state is presented in Table 1. Total aflatoxin contaminations were observed to be profound in samples from open markets as it ranged from 39.53 to 69.50 µg/kg. This could be due to the non-selective measures on roasted or ready-to- eat groundnut samples which are usually brought for sale without cleaning up the outer seed cover. However, levels of aflatoxin contaminations in groundnut samples from the super-markets ranges from 10.56 to 53.02 µg/kg. Afolabi et al., 2015 reported the presence of AFB1 at 1.3-59.1 µg/kg in roasted groundnut sold along road side while Bankole *et al*., (2005) reported concentration ranging from 5 to 165 ppb of Aflatoxin B1 in all aflatoxin-positive samples which he sampled from south western part of Nigeria and concluded that they might present potential health hazards to consumers. This might be associated to the fact that ready-to-eat-groundnut supplied to super-markets are usually cleaned up of their outer seed coats and carefully sorted based on the physical observations of any defect. RTE foods are a broad and diverse food category, prepared and stored in different ways and under different conditions, some of which support growth of some selected mycotoxins at specific storage and shelf-life conditions. The level of aflatoxins food contaminations cannot really be compared due to non- homogeneity of climatic conditions and agricultural practices among other factors (Williams, *et al*., 2004). To protect humans and animals from the harmful effects of mycotoxins, especially aflatoxin, the European Commission (EC) and international communities have proposed maximum allowable limits for aflatoxins in foods and feeds. It usually between 4-30ppb, depending on the country, for example, it 20ppb (20 µg/kg) in the USA (Ingenbleek, *et al*., 2019). Contamination by these fungi could have occurred during the removal of the skin of the seeds after roasting or when the snack is being distributed into nylons or by cross infection from other products displayed for sale in the markets.

Table 1: Total aflatoxin contamination of Ready-to-eat groundnut from two open and two super-markets in Kano

Aflatoxin (µg/kg)	Sample Codes							
	OM1 GR1	OM1 GR2	OM2 GR1	OM2 GR2	SM1 GR1	SM1 GR2	SM2 GR1	SM2 GR2
B1	36.46	35.97	63.24	95.48	10.86	13.11	9.61	48.25
B2	0.80	0.79	1.39	2.10	0.24	0.29	0.21	1.06
G1	1.60	1.58	2.78	4.20	0.48	0.58	0.42	2.12
G2	1.21	1.19	2.08	3.15	0.36	0.43	0.32	1.59
Total	40.07	39.53	69.50	104.92	11.934	14.411	10.558	53.020

OM1 and OM2 represent open markets 1 and 2; SM1 and SM2 represent Super-markets 1 and 2; GR1 and GR2 represent groundnut replicate samples

Table 2 presents the level of polycyclic aromatic hydrocarbons in smoke-dried fishes from open and super-markets of Kano state. All PAHs were detected in all samples except for BT-1, JF-2 and SH-1where fifteen, fourteen and twenty-two PAHs were only detected. Polycyclic aromatic hydrocarbons which are formed during incomplete combustion of organic matters are ubiquitous in the surrounding atmosphere and play important role in cancer risk assessments (Rengarajan, *et al*., 2015). Fish smoking is one of the many ways PAHs are formed. These compounds differ in their toxicity and carcinogenicity depending on their respective hydrophobicity.

The highest of any single PAHs of record in this study was the Benzo[a] pyrene with 26.28 µg/kg and 201.9 µg/kg in BT-1 and SH-1 respectively. The EU maximum limit for Benzo[a] pyrene for fish and fish products range between 2 to 10 µg/kg (EFSA, 2008). The high levels of total PAHs in each sample might not only be due to smoking of fishes alone, but also, due to PAHs contaminated fish feeds during aquaculture (Nnaji and Ekwe, 2018). Benzo[a] pyrene is generally used as exposure markers for cancer risk assessments and thus considered one of the most carcinogenic PAHs (Lee and Vu, 2010). Benzo[a] pyrene, benzo[a] anthracene and naphthalene have been reported with embryo toxicity in animals, thus making these PAHs of frontline concerns (Rengarajan, *et al*., 2015). In this study, samples from JF-1, JF-2, YM-1 and YM-2 perhaps had values for PAHs above 2 µg/kg but were all below 10 µg/kg maximum limit. This could affirm the report of Nnaji and Ekwe, 2018 that not only smoking of fishes but also could be from feeds used during aquaculture. In this study, PAHs values of ≥10 µg/kg were naphthalene in BT-1, Acenaphthene and Acenaphthylene in BT-2, S-methyl chrysene in BT-1, Benzo[a]pyrene in BT-1 and BT-2, chrysene, pyrene, benzo[a]pyrene, benzo[j]fluoranthene in BT-1 and SH-1samples, Dibenzo [a, h] pyrene in BT-1, Dibenzo [a, i] pyrene in BT-1 and BT-2, benzo[jhi] perylene in BT-2 and SH-2 samples. Samples from BT-2 and BT-1 followed by SH-1 and SH-2 recorded the highest sum of PAHs than other samples.

Table 2: Polycyclic Aromatic Hydrocarbons (PAH) levels of Ready-to-eat smoke-dried fish from two open and two super-markets in Kano

Polycyclic Aromatic Hydrocarbons (PAHs)	PAHs (µg/kg) in Smoke-Dried Fish samples							
	BT-1	BT-2	JF-1	JF-2	SH-1	SH-2	YM-1	YM-2
Naphthalene	12.78	4.23	2.71	1.95	8.64	8.78	1.91	2.07
Anthracene	9.70	9.04	2.07	2.10	8.91	7.28	2.03	2.10
Acenaphthene	5.74	11.27	2.87	2.67	5.23	6.52	2.65	2.76
Acenaphthylene	9.49	14.15	2.71	3.17	9.09	5.16	2.74	2.62
Fluorene	9.26	7.48	2.71	2.98	6.10	3.32	3.28	3.20
Phenanthrene	9.55	8.16	3.42	2.70	23.98	3.08	2.90	3.00
S-methyl chrysene	10.73	5.80	2.97	2.88	7.36	4.12	2.86	2.79
Benzo[a] anthracene	14.34	10.09	2.94	2.92	7.73	5.62	3.05	3.82
Benzo[b] fluoranthene	19.30	6.85	3.22	2.35	10.53	2.80	3.28	2.74
Pyrene	19.12	4.13	3.39	2.28	10.90	2.40	3. 40	3.30
Chrysene	18.30	6.79	2.45	2.54	13.69	5.69	2. 49	2.37
Benzo[a]pyrene	**26.28**	3.19	2.39	2.20	**20.19**	4.52	2.28	2.18
Benzo[j] fluoranthene	14.07	3.60	2.86	2.29	13.31	3.55	2.60	2.70
Dibenzo[a,h] pyrene	14.01	4.36	2.32	2.15	9.37	4.34	2. 42	2.39
Dibenzo[a,i] pyrene	11.34	17.52	2.42	2.39	ND	4.38	2.05	2.30
Dibenzo[a,l] pyrene	ND	4.41	2.16	2.09	ND	12.35	2.20	2.16
Indole[1,2,3, cd] pyrene	ND	4.16	2.22	2.32	ND	4.09	2.38	2.38
Cyclopenta [cd] pyrene	ND	5.29	2.50	2.78	ND	5.85	2.13	2.15
Benzo[ghi] perylene	ND	24.45	2.68	2.85	ND	18.89	2.38	2.54
Benzo[k] fluoranthene	ND	8.55	3.12	2.38	ND	9.29	2.75	2.72
Benzo[c] fluorine	ND	12.19	2.51	2.24	ND	5.05	2.94	2.94
Dibenz[a,h] anthracene	ND	11.77	2.37	2.15	ND	6.05	2. 44	2. 42
Dibenzo[a,e] pyrene	ND	10.62	2.07	ND	ND	4.62	2.25	2.19
Fluoranthene	ND	6.32	2.08	ND	ND	3.00	2.14	2.08
Σ PAHs	*204.01*	*204.42*	*63.16*	*54.38*	*155.03*	*140.75*	*50.8*	*59.5*

BT-1 = open market BT sample 1; BT-2= open market BT sample 2; SH-1= supermarket SH sample 1; SH-2= super market SH sample 2; JF-1= supermarket JF sample 1; JF-2= supermarket JF sample 2; YM-1=, open market YM sample 1; YM-2= open market YM sample 2. *Σ PAHs represent summation of sample PAHs. The levels of PAHs contamination are statistically (P<0.05) different between all market fish samples.*

Table 3 presented the levels of hydrogen cyanide in '*Garri*' samples obtained from both open and super-markets in Kano state. Each value was as extrapolated from figure 1 standard curve equation of $y = 0.0019x+0.019$ where y represented the value of absorbance and x represented the concentration. Samples from super-markets had cyanide contents ranging between 0.0696± 0.15 to 0.0723± 0.50 mg HCN/10g while samples from open markets had HCN range between 0.0428± 0.01 to 0.0811± 0.10 mg HCN/10g. '*Garri* are made from sweet cassava cultivars which are grouped of varieties with less than 50mg HCN /Kg (Ginting, 2011).

These results inferred that the cassava varieties used in the making of these '*Garri*' sample had undergone serious processing which must have precipitated more than 95% of the potential hydrogen cyanide that would be produce by hydrolysis of cyanogenic glycoside (Onabolu, 2002; Bradbury, 2006). The content of hydrogen cyanide in root crops especially cassava is dependent of the variety and the extent of processing into products (Ginting and Widodo, 2012). Hydrogen cyanide formed due to hydrolysis of cyanogenic glycoside become more volatile at temperature ≥25°C when cassava tissues are undergoing processing into products (Cardoso, *et al*., 2005).

Table 3: Hydrogen cyanide Contents of '*Garri*' samples from Open and Super-markets in Kano State.

Garri Sample	Cyanide content (mgHCN/10g)	Equivalence (ppm)	Relative % to LC_{50} (10ppm WHO limit)
SM_1G_1	0.0723± 0.50	7.23	27.7
SM_1G_2	0.0718± 0.10	7.18	28.2
SM_2G_1	0.0701± 0.50	7.01	29.9
SM_2G_2	0.0696± 0.15	6.96	30.4
OM_1G_1	0.0681± 0.15	6.81	31.9
OM_1G_2	0.0428± 0.01	4.28	57.2
OM_2G_1	0.0529± 0.15	5.29	47.1
OM_2G_2	0.0811± 0.10	8.11	18.9

Values are presented as means ±SD of three replicate experiment. **SM_1G_1** = supermarket 1 *Garri* 1; **SM_1G_2** =supermarket 1 *Garri* 2; SM_2G_1 supermarket 2 *Garri* 1; **SM_2G_2** super-market 2 *Garri* 2; **OM_1G_1** = open market 1 *Garri* 1; **OM_1G_2** == open market 1 *Garri* 2; **OM_2G_1** = = open market 2 *Garri* 1 ; **OM_2G_2** = = open market 2 *Garri* 2

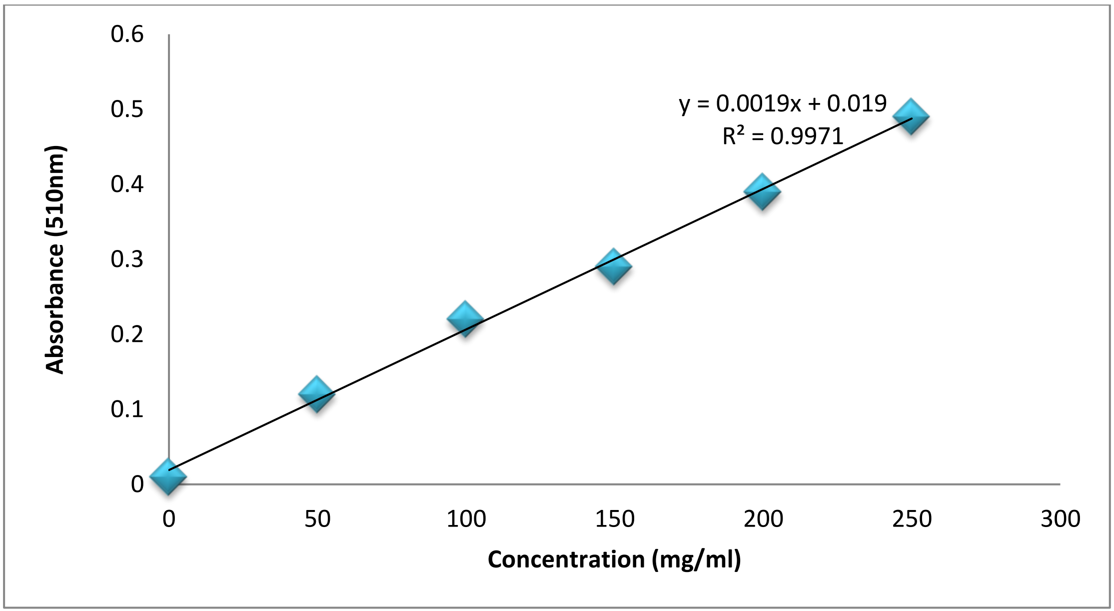

Figure 1. Standard curve of Hydrogen Cyanide

Extremely high dose of HCN beyond which the body can detoxify would result in stomach pains, headaches, dizziness, nausea and many a times diarrhea **(Burns, 2012**). With reference to Burns' assertion (2012), it can be deduced, that the more surface area of cassava products, the lesser the cyanide contents. Therefore, none of the *Garri* sampled for this study have hydrogen cyanide contents of heath concern.

CONCLUSION

Food safety has become more important than ever due to awareness by consumers and ensuring consumption of contaminated foods will go a long way in addressing this issue. PAHs, hydrogen cyanide levels were above safe limits on some instances, however the limits were not exceeded in some commodities. The high level of benzo (α) pyrene observed in one of the samples in open and supermarket is a major concern while the high level of hydrogen cyanide is below safe limit. This calls for training on improved processing and enlightenment on the dangers of consuming contaminated foods. Food safety is best ensured by the shared responsibility of everybody involved with food from the professional to the consumer which if neglected become a very serious public health problem.

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Toxicological Effects of Short-term Exposure of Rat to Arsenic and Protective Role of Ginger (*Zingiber officinale)*

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ABSTRACT

Arsenic is an environmental toxicant, and the exposure can occur through the workplace and food. Due to Arsenic toxicological effects, exposure to humans can cause degenerative disorders. This study examined the toxic effect of arsenic and the protective roles of Ginger (Zingiber officinale) on experimental rats exposed to arsenic. Animals were divided into three groups: the control group that received the normal feed, the Arsenic group fed with arsenic-contaminated feed, and the Arsenic + Z. officinale group that received arsenic-contaminated feed with Zingiber officinale for 90 days. The animal's percentage weight, hematological analysis, biochemical evaluation, and DNA damage in comet and micronucleus assays were determined. The results were analysed using the Graph pad prism. Results obtained revealed that co-administration of Arsenic contaminated feed with Zingiber officinale decreased the weight of the animals. When compared to Zingiber officinale and control group, the results showed that exposure to Arsenic for 90 days decreased the amounts of white blood cells and red blood cells. The result showed a significant increase in liver enzymes (AST, ALT and GGT), and Arsenic contaminated group also had higher levels of Urea and Creatinine than expected. Normal and arsenic–contaminated groups in the treated group showed a significant difference. Arsenic was shown to affect hepatocytes and caused DNA damage in comet and increased %MNPCE in micronucleus assay however co-administration of Zingiber officinale restored the hepatocytes to normal and decreased the level of %MNPCE. This study demonstrated that eating foods polluted with arsenic has toxicological consequences on the body but adding spices like Zingiber officinale to regular meals can protect us from these effects.

Keywords: Arsenic, *Zingiber officinale*, Body weight, Hematology, Biochemical analysis, Genotoxicity

INTRODUCTION

When compared heavy metals to water, the metallic elements with a comparatively high density of metals are referred to as heavy metals (Alam et al., 2020). Heavy metals also include metalloids like arsenic, which might have low toxicity when exposed to the environment and on the basis of its heaviness and toxicity (Luo *et al.*, 2020). The public health issues brought on by the environmental degradation by these metals have gotten worse in recent years. Due to the exponential rise of a variety of industrial, agricultural, residential, and technical applications, exposure to organisms has also substantially expanded (Proshad *et al.*, 2020).

Heavy metals are divided into two essential and non-essential categories. Essential heavy metals, also referred to as micronutrients, include; cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn), and are needed for a variety of biochemical and physiological processes (WHO/FAO/IAEA, 1996)

One example of heavy metal is arsenic. It is a common element that can be found in soil, water, food, air and it comes from both natural and artificial sources, and it is also released into the environment. Arsenic consequences range from immediate death to long-term ones like cancer and cardiovascular disorder. Based on known or suspected toxicants, arsenic is ranked first among toxicants that pose a significant risk to human health (Zheng *et al.*, 2022).

The spice ginger (*Zingiber officinale*) is one of the most popular in the world. It has a long history of use as herbal remedy for conditions like indigestion, discomfort, vomiting, and cold-induced disorders (Zhang *et al* 2021). Ginger is well known for its antioxidant, and anti-inflammatory, and anticancer properties. The volatile oils and different phenolic compounds like gingerols, shogaols, zingerone, and gingiberols are regarded to be the active ingredients in ginger. One potential mechanism for scavenging oxygen free radical and reducing the generation of reactive oxygen species (ROS) has been identified as the antigenotoxic activity of ginger (Celik, 2020). This study was done to determine the toxicological effects of short-term exposure of rat to arsenic and protective role of ginger (*Zingiber officinale)*

MATERIALS AND METHODS

Plant collection and Identification: From the area of Sabo Baptist Church Market, in Ogbomoso, *Zingiber officinale* was gathered. It was blended into a powder at the market and packaged for the animal.

Experimental Animal: Seventeen male Wistar rats (weighing between 120-160grams) were bought from Mama Rat Animal Holding in Ogbomoso, Oyo State. Animals were maintained in polycarbonate cages and placed in the animal house under regular conditions. They have undergone two weeks of acclimatization in a chamber with 12hour light/12hour dark photoperiod schedule at a temperature of 32 ± 2°C. The normal group received only food, the second group received food infected with arsenic and the third group received food infected with arsenic + ginger

Contamination of feed with heavy metal: Feeds + Heavy metal (Arsenic) + Supplement or Spices (ginger)

Feed contamination is accomplished by combining the heavy metal and the feed's raw powder separately. Following the addition of spices, the final combination is then converted into granules for the rats to easily consume at the Ladoke Akintola University of Technology Ogbomoso animal house.

Biochemical analysis: Prior to biochemical analysis, the clot-filled blood in the lithium tubes was spun at 3000 g for 10 min to separate the serum (supernatant) and stored at −70 ◦C. WBC, HGB, HCT, RBC, PLT, and %LYM were the hematological parameters that the obtained blood was examined for using an auto analyzer. Standard techniques were used to evaluate the serum biochemical indicators, according to Constantino, Serum functional test indicators for the liver and kidneys were measured (Constantino, 2017). Utilizing HAICE®, DR 3000, (Germany), the absorbance for each reaction were determined spectrophotometrically. Jiraungkoorskul et al., 2007's protocol for the micronucleus and comet assay was followed.

Statistical Analysis: Microsoft Excel and Graph pad prism 5 were used for the statistical analysis. Analysis of variance was used to analyze the outcome (One way ANOVA).

RESULTS

Percentage change in body weight of rats fed with Arsenic-contaminated feed after 90 days of exposure.

Table 1: As shown in this table, the percentage weight growth of rats fed with arsenic contaminant feed decreased significantly from 30 days to 90 days as compared arsenic-contaminated with *Z.officinale* to normal group. There was a significant difference when compared arsenic to arsenic + *Z.officinale* after 90days of exposure.

	% Body weight gain		
Group	30days	60 days	90 days
Normal	21.66^{a}	4.88^{a}	4.26^{a}
Arsenic-contaminated feed	27.91^{b}	15.64^{b}	12.17^{c}
Arsenic-contaminated feed + Ginger	25.84^{a}	15.39^{b}	8.71^{b}

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

Normal control

d- Not significantly difference when compared treated group to normal

e- Significantly difference when compared arsenic and arsenic+ *Z.officinale* to normal

f- Significantly difference when compared the arsenic to arsenic+ *Z.officinale*

The effect of Arsenic and *Z.officinale* on the hematological parameters of Rats.

Table 2: The data from this table below indicated how *Z.officinale* and arsenic affected the rat's hematological parameters. After 90 days of exposure, the arsenic contaminated feed group and arsenic contaminated with *Z.officinale* group showed a significantly lower levels of WBC, RBC and other parameters as compared to the control group (p<0.05). After 90 days of rat exposure, there was no significant difference between the arsenic contaminated feed group and the normal control group in RBC, HGB and PLT (p<0.05). However, there was no significant different when compared arsenic and arsenic with *Z.officinale* in RBC, HCT and HGB.

Parameters	**Duration**	**Normal**	**Arsenic-contaminated Feed**	**Arsenic contaminated feed + Ginger**
WBC($X10^{3}$)/μL	30 days	15.63±1.09	$12.60±1.97^{b}$	$10.23±1.89^{b}$
	60days	15.06±1.71	$10.59±1.03^{b}$	$13.98±0.81^{a}$
	90 days	11.25±1.45	$4.40±0.46^{b}$	$5.56±0.52^{a}$
RBC($X10^{6}$) μL	30 days	29.83±0.35	$23.10±0.44^{a}$	$26.93±0.97^{a}$
	60days	6.08±0.22	$3.28±1.60^{b}$	$6.22±0.30^{a}$
	90 days	8.16±0.28	$6.60±0.45^{a}$	$7.12±0.34^{a}$
PLT ($X10^{3}$	30 days	754.0±126.0	$500.0±53.80^{b}$	$615.3±106.7^{b}$
	60days	974.3±238.8	$628.6±110.6^{b}$	$769.0±123.2^{b}$
	90 days	533.2±61.89	$340.7±10.00^{b}$	$402.3±55.72^{b}$
HCT	30 days	50.40±1.30	$31.53±2.20^{a}$	$40.47±1.68^{a}$

	60days	15.06±1.70	10.59±1.02 [b]	13.98±0.81[a]
	90 days	47.27±1.48	36.30±2.40 [a]	39.63±0.92 [a]
	30 days	15.07±0.47	12.07±0.47 [a]	14.90±0.61 [b]
	60days	16.74±0.21	12.37±3.09 [b]	13.83±9.83 [b]
HGB	90 days	10.63±0.20	7.15±0.65 [a]	9.57±0.23 [a]
	30 days	79.93±3.11	69.83±3.51[a]	76.40±10.37 [b]
	60days	71.06±2.69	50.06±10.81 [b]	65.58±0.68 [a]
%LYM	90 days	75.27±1.91	66.80±11.40[b]	74.80±5.87 [a]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

Normal control

d- Not significantly difference when compared treated group to normal

e- Significantly difference when compared arsenic and arsenic+ *Z.officinale* to normal

f- Significantly difference when compared the arsenic to arsenic+ *Z.officinale*

The Effect of Arsenic and *Z.officinale* on the hepatic function and renal function levels.

Table 3: The results showed that, when compared arsenic contaminated feed group to normal group, the levels of AST, ALT and GGT increased significantly, however, in the arsenic contaminated with *Z.officinale*, the levels of AST, GGT and ALT significantly increased when compared to normal group. The results from this table demonstrated a substantial difference in urea level and creatinine level between normal group, arsenic-contaminated diet and arsenic contaminated with ginger. When compared to the normal group, the arsenic-contaminated group and the arsenic-contaminated with *Z.officinale* group both have higher levels of creatinine. There was a significant difference when compared arsenic-contaminated group and the arsenic-contaminated with *Z.officinale* group in AST and ALT but there was no significant different in GGT.

GROUP	AST(μ/L)	ALT (μ /L)	GGT (μ /L)	UREA	CREATININE
NORMAL	50.93±6.63	69.79±7. 10	56.45±2.65	30.91±1.32	90.00±16.21
Arsenic contaminated feed	123.50±46.07 [b]	156.50±38.75 [b]	60.77±1.94 [a]	50.71±0.56 [a]	125.50±23.67[b]
Arsenic contaminated feed +Ginger	98.80±60.15[b]	104.80±95.22 [b]	58.71±5.93 [b]	45.94±8.52 [b]	107.00±80.67[b]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

The Effect of Arsenic and *Z.officinale* on the %MNPCE and % tail DNA of Rats fed.

Table 4: The results of this study demonstrated that after 90 days of exposure to arsenic, the %MNPCE level in the normal group dramatically increased when compared to arsenic contaminated group but there was little difference when compared to arsenic with *Z.officinale* group, whereas there was no significant different when compared arsenic to arsenic with ginger . According to the comet results, after 90days of exposure, there was a significant difference between the arsenic-contaminated group and the normal group, but not between the arsenic

contaminated + *Z.officinale* group and the normal group, while there was a significant different when compared arsenic to arsenic with *Z.officinale*.

Parameters	Duration	Normal	Arsenic	Ginger
Comet	30days	13.85±0.37	15.88±1.34[a]	14.96±0.30[a]
	60days	11.56±0.78	13.80±0.59[b]	12.12±0.13[a]
	90days	12.26±0.21	14.90±0.36[b]	13.19±0.36[b]
%MNPCE	30 days	2.90±0.22	3.89±1.08[b]	3.02±1.38[a]
	60 days	0.80±0.05	1.56±0.47[b]	1.48±0.57[b]
	90days	0.32±0.01	1.47±0.21[b]	0.55±0.05[a]

Value was expressed as mean± SEM and considered significant at P value <0.05 after 30-90days of exposure

DISCUSSION

Toxicants are ingested and are carried by the blood to many different organs, including the liver and kidney where they may have negative consequences in the body. In this study, the amount of weight growth experienced by rat fed with arsenic contamination and the healthy control group declines over time. According to recent studies, *Z.officinale* may help people lose weight and prevent obesity-related disorders (Suk *et al*, 2017). Hemolytic anemia, infections, inflammation-tissue necrosis and stress are examples of benign disorders that can result in Leukocytosis and thrombocytosis (Claire *et al.*, 2021). RBC, HTC and HGB levels in the exposed with arsenic rat group and arsenic+ *Z.officinale* group significantly decline with time from 30 to 90 days which is a sign of anemia which could be as a result of gastrointestinal tract bleeding suggesting that arsenic suppresses the immune system. According to Aysel *et al*, (2016), administration of arsenic+ *Z.officinale* result in the preservation of haematological parameters.

Because liver enzymes are secreted into the extracellular space by hepatocytes, they are employed as indictors of liver damage (Zhang *et al*, 2020). When hepatocytes are harmed or eliminated, the liver releases alanine and aspartate aminotransferases. When arsenic poisoning causes hepatocellular damage, the serum activity of these enzymes increases. Apart from the arsenic-contaminated diet mixed with *Z.officinale* in the exposed rat, liver enzymes AST and ALT were higher ($p<0.05$) in the arsenic exposed rat compared to the arsenic+ *Z.officinale* rat. According to Talpur *et al*, (2013), supplementing *Z.officinale* in rat diets as an alternative to antibiotics and therapeutic drugs had significantly as an additive and may improve the immune status of rats, however in GGT the exposed rats are significantly higher compared to arsenic+ *Z.officinale* rat. The arsenic contaminated exposed group shows a significant increase which trend in the exposure period of the rat when compared to arsenic+ *Z.officinale* rats. The micronucleus test is determined using %MNPCE in the blood of exposed rat and normal rat, arsenic-induced toxicity has been linked to a number of mechanisms, including the inhibition of several enzymes involved in DNA repair and expression, which are responsible for the types of genotoxic damage seen in this work (Andersen et al., 2018).

As a sensitive, quick and affordable method for detecting DNA strand breakage, the comet assay is an excellent non-specific indicator of genotoxicity in rats (Andersen et al., 2018). After 90 days, the amount of DNA damage found in the tissue of rats exposed to an arsenic contaminated diet increased. *Z.officinale* played a protective role which could lead to the decrease in the level of arsenic in the tissue which result in repaired DNA, the loss of cells with severely damage DNA, or both (Muller et al., 2021). The toxicology of a contaminant that could interfere with the enzymatic activities in the generation of DNA damage may be the cause of the inverse association between time of exposure and DNA damage (Muller et al., 2021).

CONCLUSION

These findings suggested that care should be given to long-term exposure to feed contaminated with arsenic. In this investigation, arsenic was specifically found in the rat liver as evidenced by the micronucleus assay that was carried out. *Z.officinale*, which has numerous biological properties including antioxidant, anti-inflammatory, antibacterial, anticancer, neuroprotective, hepatoprotective, cardiovascular protection, and antidiabectic, can be used to evaluate the degree of exposure and damage, potentially reverse these effects.

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Proximate analysis of a fresh and smoked African Catfish (*Clarias gariepinus*) purchased from Alimosho market Lagos State, Nigeria

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ABSTRACT

The proximate and mineral composition of the commonly consumed fresh and smoked Clarias gariepinus (Catfish) was determined in this study. The fish was purchased from a fish farm in Alimosho area (Lagos) and divided into two parts: fresh fish while the other part was smoked using smoking kiln for 15 hours. The fish was analyzed using the standard methods for proximate analysis (moisture, fat content, ash content, crude fibre, protein content, total carbohydrate (all in %) and energy value (kcal) and Atomic Absorption Spectrophotometer was used to determine the mineral composition (Ca, K, Mg, Na, Zn, Fe, Cr). Analysis of variance (ANOVA) was carried out using F-test to determine the treatments level of significance. The result presented is mean value of each determination± standard error (SE). The results of proximate analysis of the catfish samples shows that there is an increment in the nutrition value of the smoked catfish except with the reduction in the moisture content (58.10±0.17 to 7.74±0.16%) which indicated the stability of the fish. The changes in proximate composition were found to be significant for the smoked catfish. The mineral analysis results ranged from 1.02±0 to 251.52±0.01 ppm in fresh catfish samples while the smoked samples ranged from 1.21±0 to 290.08±0.01ppm with sodium as the highest and chromium as the least mineral. From this study, the proximate parameters and essential minerals in Clarias gariepinus can help in complementing the nutritive values derivable from the consumption of these fish.

Keywords: *Clarias gariepinus*, smoking kiln, fresh and smoked catfish, proximate and mineral Analysis

INTRODUCTION

For many people, fish is a vital part of their diet and frequently delivers the essential elements for a healthy lifestyle. It is a wonderful component of the human diet because of its

characteristic as a cheap source of animal protein, which is now widely acknowledged around the world (Iheagwara, 2013). Currently, fish protein is preferred over other proteins of animal origin since it compares favorably to those found in meat, eggs, and milk in terms of amino acid content (Iheagwara, 2013). In developing countries like Nigeria, where the staple diet predominately consists of starchy foods, fish protein is essential for many individuals as a diet supplement (Idris, 2010). Despite the fact that fish is a necessity, a significant incidence of fish rotting still occurs in Nigeria due to a lack of storage facilities, which severely hampers the development of the fishing business in Nigeria (Akinpelu et al., 2013). Fish spoilage can be decreased using a variety of preservation techniques, including freezing, smoking, drying, brining, and chilling, according to Akinola et al. (2006). This was demonstrated, according to Bellagha et al. (2007) that indigenous methods of preservation, including as salting, drying, and smoking, have evolved over time due to the perishable nature of fish. The artisanal fishing industry places a lot of emphasis on fish smoking as a processing and preservation technique. It improves the flavour and increases utilization of the fish in addition to decreasing wastes when catches are good and influences protein availability to rural people (Ndimele, 2011). According to a review by Kiin-Kabari et al. (2011), smoked fish plays a significant role in the local diet of Nigerians, as evidenced by its delectable flavor and taste. Additionally, it has been observed that the smoked fish improves the product's flavor and aroma, lengthens shelf life due to its antioxidant and antibacterial properties, lowers pH levels, imparts a pleasing colour, hastens drying times, and acts as a preventative against spoiling. Also, it reduces waste, especially during times of abundant catches, enables for storage during the rainy season, boosts the population's access to protein year-round, and simultaneously makes fish preservation easier to pack, transport, and market.
Clarias gariepinus is one of the species of catfish which is highly nutritious. *Clarias gariepinus* is low in carbohydrates and contains high percentage of vitamins, proteins, minerals with low saturated fat, (Idris et al., 2010). It is an economically important freshwater fish and is accepted worldwide. It is cultivated extensively in ponds but is sometimes short-priced (Kumolu-Johnson et al., 2010). *Clarias gariepinus* is a very important fresh water fish in Nigeria as it accepted worldwide in most parts of the country because of its unique taste, flavour and texture (Ayeloja et al., 2011).

The knowledge of their proximate and essential mineral compositions is very important for the determination of their quality and adequacy in the diet of the consumer. Thus, it is recommended to have vital information on the proximate and mineral composition of catfish for human consumption as well as comparing the results with the recommendation limit so as not to pose hazard on human health. This study, therefore, aims to determine the proximate analysis and mineral composition of fresh and smoked catfish species in Alimosho area, Lagos State. This location was chosen based on the fish marketers.

METHODOLOGY

Fish Sample and Preparation: Melunch sizes of Fresh catfish (*Clarias gariepinus*) (20kg) samples were purchased from a reputable fish farm in Alimosho area, Lagos State. Some of the fish samples were immediately transported in an oxygen bag to the Sofunk foods processing unit command Ajasa Alimosho Lagos following the hygienic protocol for smoking while others were transported to Federal Institute of Industrial Research Oshodi (FIIRO) and Nigeria Institute for oceanography and Marine Research (NIOMR) for chemical analysis. The catfish samples for analysis were divided into two (fresh and smoked).

The first part of the samples (fresh catfish samples) were properly washed, cleaned, degutted and blended in an electrical grinder machine to smaller sizes to increase the surface area for further analysis and it was stored in a refrigerator for prior use. For the second part, the clean degutted catfish samples were smoked for 15 hrs using a smoking kiln and was allowed to cool for 8 hrs before being pulverized for further chemical analysis.

Chemical Analysis: The fresh and smoked catfish samples were homogenized after which proximate composition (moisture, ash, crude fibre, fat, protein total carbohydrate and energy value) was determined using the standard methods of AOAC (1994) and mineral composition (Ca, K, Mg, Na, Zn, Fe and Cr) were also determined using Atomic Absorption Spectrophotometer (AAS)

Statistical Analysis: Data obtained were subjected to Analysis of variance (ANOVA) which was carried out using F-test to determine the treatments level of significance. Treatments were separated using Duncan Multiple Range Test (DMRT) to compare mean differences at 5% level of probability. The result presented is the mean value of each determination ± standard error (SE).

RESULTS AND DISCUSSION

The results of the proximate analysis of the fresh and smoked catfish samples are presented in Table 1. From the result, the moisture content of the fresh catfish samples was lower than that of the smoked samples with moisture content of 58.10±0.17 and 7.74±0.16, respectively. The moisture contents of the two fish samples (fresh and smoked) were within the range of the previous finding (Elagba and Rabie, 2010; Ajai et al., 2019). The stability of food substance is usually measured by its moisture content which also affects the composition of both protein and lipid (fat) contents (Olagunju et al., 2012). In this study the crude protein had the highest composition based on dry matter, which is an indication of dietary quality. The protein results is comparable to results obtained by Ajai et al. (2019) (11.65±1.99 and 41.15±1.87 for fresh and oven-dried *Clarias gariepinus*, respectively) and Ayeloja et al. (2015). Increase in fat content in the smoked sample could be as a result of salting and smoking due to the oxidation of the polyunsaturated fatty acids (PUFA) contained in the fish tissue into peroxides, aldehydes, ketones and the free unsaturated fats by these additives (Holma and Maalekuu, 2013).

Table 1: Proximate analysis of fresh *Clarias gariepinus* fish (catfish)

Parameter	Mean ±SE	
	Fresh	**Oven-dried**
Moisture (%)	58.10±0.17^{c}	7.74±0.16^{b}
Ash content (%)	5.32±0.02^{a}.	5.69±0.09^{c}
Crude fibre (%)	0.14±0.02^{a}	3.90±0.12^{c}
Fat content (%)	6.95±0.15^{a}	12.29±0.17^{b}
Protein content (%)	27.39±0.11^{a}	48.53±0.11^{b}
Total carbohydrate (%)	2.11±0.40^{a}	21.84±0.05^{b}
Energy value (kcal)	180.51±0.47^{a}	392.12±1.56^{b}

Results are Mean ± Standard Error of triplicate analysis. Those with different superscripts are significantly different, while those with similar superscripts are not significantly different at p ≤ 0.05.

Table 2: Mineral analysis of fresh *Clarias gariepinus* fish (catfish)

Parameter (ppm)	Mean ±SE	
	Fresh Catfish	**Oven-dried Catfish**
Calcium	74.07 ± 0.03^{a}	162.81 ± 0^{c}
Potassium	74.41 ± 0.01^{c}	63.14 ± 0.01^{a}
Magnesium	41.81 ± 0^{a}	48.91 ± 0^{c}
Sodium	251.52 ± 0.01^{a}	290.08 ± 0.01^{b}
Zinc	2.39 ± 0^{a}	3.07 ± 0.01^{b}
Iron	3.46 ± 0^{a}	3.58 ± 0^{b}
Chromium	1.02 ± 0^{a}	1.21 ± 0^{b}

Results are Mean ± Standard Error of triplicate analysis. Those with different superscripts are significantly different, while those with similar superscripts are not significantly different at p ≤ 0.05.

The result of the ash content concur with the findings by Bhouri et al (2010) and Ajai et al (2015),who reported an increase in ash content in oven dried fish as compared to the fresh fish. The observed range of ash content in this study indicated that the oven dried fish had a good source of minerals since ash is a measure of the mineral content of food item (Oladipo and Bankole, 2013).

Minerals are essential to the body metabolic process in living organisms. Catfish is among the most important sources of these minerals. Table 2 shows the mineral constituents of the studied fresh and smoked fish. From the results obtained in this study, the mineral composition of the samples considered varied from 1.02±0 to 251.52±0.01 ppm in fresh catfish samples while the smoked samples varied from 1.21±0 to 290.08±0.01ppm with sodium as the highest and chromium as the least mineral. Sodium is an essential nutrient involved in the maintenance of normal cellular homeostasis. It regulates fluid and electrolyte balance and blood pressure (Strazzullo and Leclercq 2014). Chromium is an essential trace element needed in the diet in small amount concentration. It helps in brain function, blood sugar control, and the breakdown of fats and carbohydrates. In this study, smoked catfish has a contributory effect on the zinc concentration as it increases its bioconcentration. Zinc serves as cofactors to some important enzymes and is also involved in most metabolic pathway in human, while its deficiency can lead to loss of appetite, growth retardation, skin changes and immunological abnormalities; however, at higher concentration they tend to be toxic (Fawole et al., 2013). Calcium is also an important mineral in the body metabolic process. It helps in the uptake of dietary Vitamin B and activation of lipase; synthesis of neurotransmitter acetylcholine and; lowers blood pressure and helps in building and maintaining bone mass (Olaniyi *et al.*, 2018). Generally, all the minerals analyzed are within the FAO/WHO (2011) recommended limit. Increase in some minerals in the smoked could be as a result of oxidation during the smoking process.

CONCLUSION

The result of this study indicated significant differences ($p < 0.05$) in the proximate composition and mineral contents of both fresh and smoked catfish. The results provided vital information on the proximate and essential mineral compositions of fresh and smoked *Clarias gariepinus* in Alimosho area, Lagos state. The smoking method of drying catfish was found to be more efficient with the reduction in moisture content, making it appropriate for export. From this study, the proximate parameters and essential minerals of *Clarias gariepinus* can assist in complementing the nutritive values derivable from the consumption of these fish.

As a result of this study, it is advised that food regulatory organizations make a valiant effort to conduct routine analyses of the nutritional composition of fresh and smoked catfish to make sure that their essential mineral contents are within the permissible limit and won't be harmful to the health of the consumers.

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Pasting Properties Of Fresh Roots And Flour Processed From Nrcri Cassava Crossing Block Trial

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ABSTRACT

Cassava roots can be are processed into different types of products such as gari, lafun, landang, fufu, flour, chips, starch akara, okpokpo garri, meal, ighu, syrups, dextrins, and alcohol

Characterizing the food and industrial potentials of different cassava varieties may be achieved by understanding the pasting properties of the roots and intermidate products such as flour.fourteen (14) elite cassava clones and a preffered land race were harvested from NRCRI cassava programe (TMS13F1160P004, TMS13F1343P0022, NR-14B-218, TMS11TA000070, TMS13F1343P0044, NR-095-F, TME 419, TMS13F1112P0005 TMS13F2110P0008, NR130022, TMS01/136810, TMS01/11412, 98/0505, Nwaocha, TMS130124.) Freshly harvested cassava clones were washed, peeled and cut into chips. The Chipped cassava roots were oven dried at 50^{o}C and milled into flour for pasting properties which was determined using a Rapid visco analyzer (RVA). NR-14B-218 had the highest final viscosity, setback value and a good pasting temperature. The good swelling potential exhibited by all the clones reveals their suitability for both baking and confectioneries.

Key words: Pasting properties, Starch, Confectioneries, Swelling potential and shelf life[

INTRODUCTION

Cassava, Manihot esculenta Crantz is an important staple food in sub-Saharan Africa. Cassava roots are processsed into products such as gari, lafun, landang, fufu, flour, chips, starch akara, okpokpo garri, meal, ighu, syrups, dextrins, and alcohol (Nwabueze and Odunsi, 2007),

Breeders have mostly focused on improving agronomic traits of varieties that could be distributed and promoted among farmers (Acheampong, 2015). However the need to inco-operate food quality attributes into breeding programs has become imperative considering the low adoption of the released improved varieties by farmers, food and industrial processors.

Characterizing cassava varieties for different food and industrial potential is therefore of utmost importance due to rapid urban growth and dynamics in market development in Nigeria. This may be achieved by understanding the pasting properties of the roots and intermidate products such as flour for food and industrial purposes.

MATERIALS AND METHODS

Fourteen (14) elite cassava clones and a preffered land race were harvested from NRCRI cassava programe crossing block experimental field (TMS13F1160P004, TMS13F1343P0022, NR-14B-218, TMS11TA000070, TMS13F1343P0044, NR-095-F, TME 419, TMS13F1112P0005 TMS13F2110P0008, NR130022, TMS01/136810, TMS01/11412, 98/0505, Nwaocha, TMS130124.)Fresh roots of the different cassava clones were washed, peeled and cut into chips. The Chipped cassava roots were sub-sampled, oven dried at 50^{o}C and milled to flour. The pasting properties of the flour was determined using a Rapid visco analyzer (RVA).

RESULT AND DISCUSSION

The table shows that peak viscosity of the cassava varieties ranged from 337.50 RVU for NR-095-F to 547.96 RVU for 98/0505. There was no significant differences (p>0.05) in the peak viscosity of the cassava varieties. Peak viscosity is an index of the ability of starch-based foods to swell freely before their physical breakdown (Adebowale et al., 2008). NR-095-F had the highest peak viscousity and starch content compared to the other clones However, these values obtained for peak variety were lower than 622.50 RVU previously reported Obadina et al., (2014) for yam Values obtained for trough viscosity ranged from 150.80 RVU (TMS13FS110P0008) to 292.88 RVU (NR-14B-218). Apart from the NR-095-F and NR14B-218 trough viscosity did not differ significantly (p>0.05) among the cassava varieties.
The breakdown viscosity of the cassava varieties ranged from 191.33 to 315.92 RVU, no significant differences (p>0.05) was observed among the cassava genotypes. The highest value of breakdown viscosity was recorded in 98/0505 (315.92 RVU). The breakdown viscosity is an index of the stability of the starch and a measure of the ease with which the swollen granules can disintegrate under shear stress (Kaur et al., 2007). A range of 159.63 to 451.84 RVU was obtained as the final viscosity of the cassava varieties. NR-14B-218 had the highest value of final viscosity (451.84 RVU), followed by TMS01/11412 (389.71 RVU) NR-095-F however had the least value for final viscosity (159.63 RVU). TMS/130124, TMS01/136810, NR130022, TMS13FS110P0008, and NR095-F; and NR-14B-218 their values for final viscosity were significantly different (P<0.05) from other cassava varieties in terms of final viscosity. Final viscosity is commonly used to define the quality of particular starch-based flour since it indicates the ability of the flour to form a viscous paste after cooking and cooling. It also gives a measure of the resistance of the paste to shear force during stirring (Adebowale et al., 2008). This study revealed that NR-095-F had the lowest setback viscosity hence a lesser tendency to retrograde indicating long shelf-life and good fridge stability compared to the other cassava varieties. The values of setback viscosity showed that no significant differences (p>0.05) among the cassava varieties apart from NR-095-F and NR-14B-218. The peak time of the cassava varieties ranged from 4.13 to 5.30 min. whereas the peak viscosity of NR-095-F was significantly different (p<0.05). NR-095-F had the highest value of peak time (5.30 min) while the lowest peak time was recorded in TMS/130124 (4.13 min). Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking (Iwe et al., 2016). The pasting temperature of the cassava varieties ranged from 65.93 to 87.10°C.). Higher pasting temperature recorded in NR-095-F indicated that its starch possess smaller granular size compared to that of other cassava varieties. Zeng et al. (2013) affirmed that pasting temperature is dependent on the size of the starch granules. pasting temperature of TMS13F1112P005, TMSIITA000070, NR-095-F, and NR-14B-218 were not significantly different (p>0.05) from each whereas the pasting temperature of TMS13F1343P0022 was significantly different (p<0.05).

CONCLUSION

The outcome of this research revealed that all clones have a good swelling potential and will be suitable for both baking and confectioneries. NR-095-F had the lowest setback viscosity hence a lesser tendency to retrograde indicating a longer shelf-life and good fridge stability compared to the other cassava varieties. NR-14B-218 is highly recommendable has it's has the perfect pasting quality.

The pasting properties of the flour

S/N	*CLONES*	Peak viscosity	*Trough*	*Break down*	*Final viscosity*	*Setback*	*Peak time*	*Pasting temperature*
1.	TMS01/136810	462.2a	162.75b	299.4a	217.58bc	54.84bc	4.30b	
2.	TMSIITA000070	489.8a	224.09ab	265.7a	350.50abc	126.42abc	4.57ab	80.800a
3.	NR-14B-218	492.1a	**292.88a**	199.2a	**451.84a**	**158.96a**	4.84ab	81.075a
4.	TME 419	449.2a	237.09ab	212.1	318.58abc	81.50abc	4.54ab	79.200a
5.	TMS13F1160P0004	431.5a	173.21ab	258.3a	227.88bc	54.67bc	4.5ab	79.600a
6.	TMS13F1343P0022	424.8	200.88ab	223.9a	275.50abc	74.63abc	4.53ab	**65.93b**
7.	NWAOCHA	455.8a	177.46ab	278.3a	243.50bc	66.04abc	4.30b	78.33a
8.	TMS98/0505	548.0a	232.05ab	**315.9a**	350.05abc	117.96abc	4.47ab	78.650a
9.	TMS13F1112P0005	420.1a	162.96b	251.1a	222.59bc	59.63bc	4.47ab	80.825a
10.	NR-095F	337.5a	126.04b	211.5a	159.63c	33.58c	5.30a	**87.100a**
11.	NR130022	391.6a	153.96b	237.7a	203.79bc	49.84bc	4.30b	79.150a
12.	TMS13F1343P0044	434.9a	243.58ab	191.3a	319.63abc	76.05abc	4.74ab	79.58a
13.	TMS13F2110P0008	407.5a	150.80b	256.7a	206bc	55.21bc	4.14b	79.23a
14.	TMS130124	413.0a	154.75b	258.3a	206.79bc	52.04bc	4.13b	79.58a
15.	TMS01/1412	**521.3a**	252.30ab	269.a	389.71ab	137.42ab	4.60ab	78.33a

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Assessment of Proximate Composition, Functional Properties and Consumer Acceptability of Ogiri Produced from Melon Seeds

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ABSTRACT

Ogiri was produced using melon seeds to determine quality and consumer acceptability. The proximate composition and functional properties was determined which gives protein content of 12.703±0.172%, moisture content of 4.717±0.041%, fat content of 20.713±0.150%, Crude fiber of 1.1700±0.030%, ash content of 1.7267±0.015% and Carbohydrate content of 59.283±0.067%. The functional properties were determined and it was also subjected to sensory evaluation in terms of taste, colour, texture, aroma and overall acceptability on 9-point hedonic scale ranging from like extremely (9) to dislike extremely (1). The sensory evaluation result shows that the consumer preferred the ogiri produced from melon with an overall acceptability 80%.

Keywords: Melon Seeds; Proximate Composition; Functional Properties; Sensory Evaluation; Ogiri; Overall Acceptability.

INTRODUCTION

Fermented food condiments have constituted a significant proportion of the diet of many people as they give pleasant aroma to soups and sauces in many countries, especially in Africa where protein calorie malnutrition is a major problem (Sarker *et al*., 2003). They also have a great potential as key protein and fatty acid sources, and are good sources of gross energy (Omafuvbe, *et al*., 2004). In Africa, many proteinaceous oily seeds are fermented to produce food condiments (Sanni and Ogbonna, 2011; Baird-Parker, 2014). Therefore, these condiments are basic ingredients for food supplementation, and are named according to the substrate or raw materials employed (Odunfa, 2005) which include "ogiri ugu" produced from fluted pumpkin seeds (*Telferia occidentallis*) and "ogiri egusi" produced from melon seeds (*Citrullus vulgaris*). Previous studies have centred on ogiri egusi (Omafuvbe *et al*., 2004; Ogueke and Nwagwu, 2007; David and Aderibigbe, 2010). Ogiri is one of the condiments consumed in the Eastern and Western parts of Nigeria (David and Aderibigbe, 2010). The seeds of castor oil (*Ricinus communis*) are one of the various substrates accentuated by many authors on the production of ogiri (Odunfa, 2005; Jideani and Okeke, 2001). Other substrates used for the production of ogiri include the seeds of water melon (*Citrullus vulgaris*), creeping melon (*Colocynthis vulgaris*) and seed of fluted pumpkin (*Telfairia occidentalis*) (Odunfa, 2011; David and Aderibigbe, 2010). However, none or little work has been reported on the comparative study and consumer acceptability of ogiri egusi production, a food condiment made from melon seeds. There is therefore the need to study the consumer acceptability of Ogiri production using melon seeds.

METHODOLOGY

Sample Preparation and Procurement

The shelled melon seeds used in this study was purchased from Towobowo market, situated in Ibarapa Central Local Government Area of Oyo state, Nigeria. The raw materials obtained were sorted, cleaned and then washed to remove all extraneous matter. They were then allowed to dry and packaged separately in a plastic bag, ready for processing. All other chemicals used in this research were of analytical grade.

Production of Ogiri from Melon Seeds

Ogiri was produced from melon seeds using the method described by Ifesan, *et al.*, (2019) with a fermentation period of 3 days.

Proximate Analysis and Functional Properties of Ogiri Produced from Melon Seeds

Proximate composition such as protein content moisture content, fat content, ash content, crude fiber and carbohydrate content and functional properties such as water absorption, swelling capacity, solubility and oil absorption were determined using the method described by AOAC (2005).

Sensory Evaluation

Sensory Evaluation was carried out according to the method described by Iwe (2010). On each of the samples using 10 trained panellists to assess the sensory attributes (appearance, aroma, texture, and overall acceptability) of the samples. The panellists were selected using simple random sampling techniques comprising staff of Oyo State College of Agriculture and Technology, Igboora who were familiar with the products as taste panelists in carrying out this research. In selecting the test. The samples were presented in plates with water to rinse mouth after each tasting. The panelists were instructed to rate the sample for the attributes based on a 9-point Hedonic scale ranging from 9- like extremely to 1- dislike extremely.

RESULTS AND DISCUSSIONS

The produced melon seeds ogiri was analyze in triplicate to obtain the proximate composition of the products as presented in table 1. The ogiri produced from melon seeds has a protein content of 12.703%±0.172, moisture content of 4.717±0.041, fat content of 20.713±0.150, crude fiber of 1.170±0.030 and carbohydrate of 59.282±0.067%. the result obtained in this study falls out within the range reported by David and Aderibigbe (2010) who observed that the moisture content of unfermented melon seeds and 4 days fermented *ogiri egusi* samples increased from 7.13% to 35.43%, ash content increased from 2.85% to 3.56%, carbohydrate increased from 11.03% to 24.43%, protein decreased from 32.27% to 29.37%, fat decreased from 50.13% to 33.95% and fibre decreased from 3.53% to2.57%. similarly, a lower value was obtained as compared with the report of Akinyele and Oloruntoba (2013) on average proximate composition of unfermented *ogiri-egusi* with crude fibre 7.14%, crude protein 37.41%, crude fat 29.55%, ash 3.17% and moisture 4.77%; while after five days fermentation, the proximate composition was crude fibre 11.43%, crude protein 33.3%, crude fat 33.54%, ash 3.17% and moisture 8.25%.

Table 1 Proximate Composition of Ogiri Produced from Melon Seeds

variables	Composition (%)
protein content	12.703±0.172
moisture content	4.717±0.041
fat content	20.713±0.150
ash content	1.7267±0.015
crude fiber	1.1700±0.030
carbohydrate content	59.283±0.067

The produced melon seeds ogiri was analyze in triplicate to obtain the functional properties of the products as presented in table 2. The ogiri produced from melon seeds has a water absorption of 78.537±0.015%, swelling capacity of 2.930±0.020%, solubility of 17.317±0.101%, and oil absorption of 84.747±0.081%.

Table 2 Functional Properties of Ogiri Produced from Melon Seeds

Variable	Composition (%)
water absorption	78.537±0.015
swelling capacity	2.930±0.020
Solubility	17.317±0.101
oil absorption	84.747±0.081

Sensory evaluation was carried out on the produced ogiri from melon seeds and the results obtained were presented in table 3 below.

Taste: From the result shown in table 3, 70% of the respondents like the taste of the ogiri produced from melon seeds extremely while the remaining 30% of the respondents like the ogiri produced from melon seeds taste very much.

Colour: The result presented in table 3 shows that 60% of the respondents like the colour of the ogiri produced from melon seeds exteremely, 30% of the respondents like the colour of the ogiri produced from melon seeds very much while the remaining 10% of the respondents moderately like the melon ogiri.

Texture: In terms of texture, 70% of the respondents like the texture of the ogiri produced from melon seeds extremely and 30% of the respondents like the texture very much as presented in table 3.

Aroma: 70% of the respondents like the aroma of the ogiri produced from melon seeds exremely, 20% of the respondents like its aroma very much, while the remaining 10% of the respondents show that the ogiri made from melon seeds is moderately like as presented in table 3.

Overall acceptability: The result presented in table 3, shows that 80% of the respondents accepted the ogiri made from melon seeds extremely while the remaining 20% of the respondents says the acceptance of the ogiri made from melon seeds with the hedonic rating of like very much.

Table 3 Sensory Evaluation of Ogiri from Melon seeds

Ranting	**Taste**	**Colour**	**Texture**	**Aroma**	**Over Acceptability**
Like extremely	70	60	70	70	80
Like very much	30	30	30	20	20
Like moderately	0	10	0	10	0
Like slightly	0		0	0	0
Neither like nor dislike	0	0	0	0	0
Dislike slightly	0	0	0	0	0
Dislike moderately	0	0	0	0	0
Dislike very much	0	0	0	0	0
Dislike extremely	0	0	0	0	0
Total	100	100	100	100	100

CONCLUSION

Food condiments are made from protein based foods and oil-seeds in which ogiri is included. Ogiri was produced from melon seeds. The proximate composition and functional properties were determined and was found to be rich in nutrients needed by human body for normal growth and development. It was later subjected to sensory evaluation using well trained panelists who are familiar with the consumption of ogiri to rate the produced ogiri from melon seeds on a 9-points hedonic scale. It was found out that, 80% of the consumer accepted the products with a rating of like extremely and 20% accepted the product with like very much rating base on the hedonic scale.

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Effect of Moisture Content and Extraction Temperature on Solvent Extraction of Oil from African Locust Bean Seeds

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ABSTRACT

African locust beans seeds with an initial moisture content of 8.04% was obtained and preconditioned to moisture content of 6%, 12%, and 18% and extraction temperature of 40^0, 50^0C and 60^0C as stated in the experimental design. Oil was extracted from the seeds using solvent extraction method, the process of extraction was investigated to check the effect of the varied moisture content and extraction temperature, maintaining a constant extraction time of 8hrs. The highest percentage oil yield of 21.05% was obtained at seed moisture contents and extraction temperature of 6% and 60^0C respectively. While, the least value of 6.51%. was obtained at seed moisture contents and extraction temperature of 18% and 40^0C respectively. The response obtained as the percentage oil yield were subjected to statistical analysis to understand the significant effect of the factors considered, a p-value lesser than 0.05. This indicated that, the moisture content of the seed is inversely proportional to the oil yield while the extraction temperature is directly proportional to the oil yield obtained from African locust bean seeds.

Keywords: Locust beans; Moisture Content; Extraction Temperature; Oil Yield.

INTRODUCTION

Natural vegetable oils and fats are increasingly becoming important in nutrition as well as the manufacturing industry worldwide. Nutritionally, vegetable oils are important sources of dietary energy. Vegetable oils account for 80% of the world's natural oils and fat supply (Okullo et al., 2010). Vegetable oils are sourced from diverse varieties of leguminous plants. With an ever increasing demand for vegetable oils for food and industrial applications, there is need for considerable expansion of oilseed crop production (Çamaş et al., 2007). This expansion can be achieved by exploring other sources of vegetable oils, especially underutilized oilseeds (Popoola et al., 2016). Locust beans (*Parkia biglobosa*) is a wild legume known for its inexpensive proteins, but the exploration of its oil content (Bhat & Karim, 2009). Its oil is suitable for consumption since it contains very low acid and iodine contents; it has essential acids and vitamins and serves as a protein supplement in the diet of poor families and has been reported to be non-toxic.

Currently in Nigeria, the focus is on groundnuts, soybeans and cotton as the main oil seeds. These sources of vegetable oil have not been able to meet the increasing demand of vegetable oil for both human and industrial use. Hence, there is need to supplement the supplies with other sources, especially underutilized oilseeds (Popoola et al., 2016). It is worthwhile to investigate the effect of process parameters that affects the yield of oil obtained from oil bearing seeds. Hence, this study was carried out to extract oil from African locust beans (*Parkia biglobosa)* by examine the effect of moisture content and extraction temperature through the use of solvent extraction method.

METHODOLOGY

Sample Collection and Preparation

African locust beans (*Parkia biglobosa)* seeds were obtained from local market in Igboora, Oyo State, Nigeria. The seeds were handpicked to remove stones and deteriorated ones. All samples were milled to fine particle size, packaged in an air tight container and then stored in the refrigerator at 4^{o}C prior to extraction.

Experimental Design

After the locust beans seeds were obtained and prepared, the experiment to be carried out were designed with the aid of Minitab 18 software using full factorial design. In designing the experiment, the factors considered were the moisture content and extraction temperature keeping a constant extraction time of 8hr while the response of each experiment was chosen to be the percentage oil yield obtained from the seed. The levels used for the factors is given in table 1. A total of nine experimental runs were obtained and the extraction was carried out using soxhlet apparatus.

Table 1 Factors and their Levels for Full Factorial Design

Variables	Symbol	Levels		
Moisture content (%)	X_1	6	12	18
Extraction temperature (◦C)	X_2	40	50	60

Moisture Content Variation

The initial moisture content determination and moisture content variation of the seeds was achieved using method described by Siyanbola, *et al.*, (2020) and Ogunsola, *et al.*, (2021).

Oil Extraction from African Locust Beans Seed Using Solvent Extraction Method.

Thirty grams (30g) of the conditioned seeds at various moisture content levels were poured and wrapped inside a filter paper of known weight. The samples were carefully inserted inside the extraction chamber which is being suspended above a round bottom flask containing 300ml of ethanol solvent and below a condenser. Heat is being applied to the flask with the aid of a

heating mantle at the desired extraction temperature. The solvent evaporates to the condenser where it is cooled and converted into liquid and falls back into the extraction chamber containing the sample.
The flask containing the solvent and oil was removed at the end of the extraction process after completing 8hr extraction time. The procedure was repeated for other sample at the specified moisture content and extraction temperature in the experimental design. The mixture of the oil and solvent were poured back into the soxhlet apparatus. Heat is being applied to the flask with the aid of a heating mantle at the temperature of 50^0C. The Solvent evaporates to the condenser where it is cooled, converted into liquid and before it falls back into the extraction chamber containing the mixture, it was then poured out into a separate container. The procedure was repeated for other sample until the solvent was completely evaporated from the oil.

Determination of Percentage Oil Yield Obtained from Locust Beans Seeds

The weight of the sample before extraction was recorded as W_i and the residue of the sample after extraction was oven dried at a temperature of 50ºC for about 1 hour in order to evaporate excess solvent present and later weighed and recorded as W_r. The percentage oil yield of each of the sample was obtained.

The percentage oil yield was calculated as follows;

% oil yield= $\frac{\text{Wi}-\text{Wr}}{\text{Wi}} * 100$ (Siyanbola, *et al.*, 2020)

Where;

W_i is the weight of sample before extraction.

W_r is the weight of the residue after extraction.

Analysis of Data

The results obtained from the experiment were analyzed with the aid of Minitab 18 software to develope response equation for analysis of variance (ANOVA) in other to determine the effects of moisture contents and extraction temperature on oil yield of African locust bean seeds.

RESULT AND DISCUSSION

The results obtained after the extraction of the oil from locust beans seeds with initial moisture content of 8.04% is presented in table 2. The two parameter factors, moisture contents and extraction temperature were combined in the experiment to obtain the percentage oil yield as the response. The variation of percentage oil yield obtained indicated that the parameters considered have effects on the extraction of oil from locust bean seeds. It was observed that the highest percentage oil yield of 21.05% was obtained at an extraction temperature of 60ºC and moisture content of 6%. While the least percentage oil yield of 6.51% was obtained at a moisture content of 18% and extraction temperature of 40ºC. The results indicate higher oil content as compared to oil yield reported by Talabi and Enujiugha (2014), Mweta and Magombo (2017) and *Olowokere et al. (2018)* for African locust bean as 20.68±0.71%, 12.06±0.26 % and 11.41±0.03% respectively. It was discovered that the variation of moisture contents with extraction temperature affected oil quantity as reported by Siyanbola, *et al.* (2020) and Ogunsola, *et al.* (2021). The higher the moisture content, the lower the percentage oil yield. This is as a result of the solvent not being soluble in water, with high moisture content, the extraction efficiency of the solvent will be reduced leading to low oil yield. Also, an increase in temperature led to increase in oil yield. This is because as the temperature increases, there is a breakdown of oil cells leading to decrease in oil viscosity and increasing the number of oil siphons which allow oil to flow more readily through. It can be deduced that the combined effects of moisture content and extraction temperature has effect on the oil quantity from African locust bean seeds. The higher result obtained in this study indicated that moisture content and extraction temperature are part of the process parameters that affect the quantity of oil obtained from African locust beans seeds.

As shown in Table 3, the p-value was used to measure how significant the effect of the factors on the percentage oil yield obtained from African locust beans seeds. From the results obtained, it was discovered that each of the factors experimented has a significant effect on the percentage oil yield of African locust beans seeds as the result of the obtained p-value was less than 0.05. The results obtained revealed that variation of moisture content and extraction temperature have a significant effect on yield of locust beans seeds.

Table 2. Factors Considered and Responses

Run Order	Moisture Content (%)	Extraction Temperature (hr)	% Oil Yield
1	12	50	11.65
2	6	40	12.37
3	18	50	9.23
4	6	60	21.05
5	6	50	18.72
6	12	40	7.40
7	18	40	6.51
8	12	60	14.78
90	18	60	10.25

Table 3. Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	4	188.000	47.000	25.61	0.004
Linear	4	188.000	47.000	25.61	0.004
Moisture Content (%)	2	120.060	60.030	32.70	0.003
Extraction Temperature (hr)	2	67.939	33.970	18.51	0.010
Error	4	7.342	1.836		
Total	8	195.342			

CONCLUSION

African locust beans (*Parkia biglobosa)* with an initial moisture content of 8.04%(wb) was obtained and preconditioned to the various moisture content of 6%, 12%, and 18% and extraction temperature of 40^0, 50^0C and 60^0C as stated in the experimental design. Oil was extracted from the seeds using solvent extraction method, the process of extraction was investigated to check the effect of the varied moisture content and extraction temperature, maintaining a constant extraction time of 8hrs. The highest percentage oil yield of 21.05% was obtained at seed moisture contents and extraction temperature of 6% and 60^{0}C respectively. While, the least value of 6.51% was obtained at seed moisture contents and extraction temperature of 18% and 40^{0}C respectively. This indicated that, the parameters varied has effect on the oil quantity. With a higher oil yield obtained in this study using solvent extraction method, this shows that solvent extraction method is more effective in removing oil from oil bearing seeds, makes the industrial practice of the oil recovery a profitable venture and will reduce the level of waste that is obtained from oil extraction.

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Aflatoxin B_1 contamination level of Nigerian groundnut cake from the six geopolitical zones of Nigeria

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ABSTRACT

In the Era of Global warming, this study was carried out to establish and obtain empirical data on the level of aflatoxin B_1 (AFB_1) contamination of Nigerian groundnut cake (GNC). It could also bring resurgence of interest in Nigerian groundnut pyramid and a re-focus of interest in nationally sourced GNC for poultry feeding which would be rewarding to the Nigerian feed sub-sector. One hundred and twenty samples of the Nigerian GNC were collected from five locations of two States from each of the six geopolitical zones of Nigeria both in the dry and rainy seasons. The levels of AFB_1 contamination of Nigerian GNC were determined using the Enzyme Linked Immunosorbent Assay (ELIZA) method. It was observed that samples from the Southern geopolitical zones recorded the higher (450.00, 500.00 and 620.00 ppb) levels of AFB_1 contamination compared to the Northern geopolitical zones with (220.00, 190.00 and 241.00 ppb). Meanwhile, the lowest (not detectable) level of AFB_1 contamination were obtained within samples from the North-East (N-E) geopolitical zone. However, the highest (620.00 ppb) level of AFB_1 contamination recorded was among samples from the South-South (S-S) geopolitical zone. Thus, with the right applications of the technological advances in transportation and storage, couple with adequate enlightenment of handlers of GNC on the best management practices, could further reduce the levels of AFB_1 contamination of Nigerian GNC.

Keywords: groundnut cake; aflatoxin B_1; contamination; enzyme-linked immunosorbent assay; not detectable; geopolitical zones.

INTRODUCTION

Groundnut is one of the plant protein source in which Nigeria has comparable advantage of production over other oil seed crops with comparable crude protein content with some other plant proteins. The northern part of Nigeria is famous for groundnut pyramids in the 1960s and early 1970s, and GNC could be easily available for livestock feeding after extraction from the groundnut. In the recent times, the cost of locally available feed ingredients such as maize, GNC and soya bean meal (SBM) have become sky-rocketed due to obvious reasons such as crop failures occasioned by climatic change (Ezihe *et al.*, 2017, Siamabele and Moral, 2021). The direct impact of these on the poultry industry is shortage of the major raw materials needed for feed production. Pre- and post-harvest infection by storage moulds and subsequent mycotoxin accumulation in groundnut seeds are serious problems in the tropical hot and humid areas of the world (Mohammed *et al.*, 2016). The mycotoxins produced by these moulds are toxigenic contaminants of food and feeds that are frequently responsible for health and economic concerns in many countries (Bhatnagar *et al.* 2003). Aflatoxins (AFs) are a group of naturally occurring highly carcinogenic compounds which are mainly produced by *Aspergillus flavus, Aspergillus parasiticus* and *Aspergillus nomius* (Strosnider *et al.* 2006). There are different variants of aflatoxin of which the most abundance and importance are aflatoxin B_1, B_2, G_1 and G_2. Among these, AFB_1 is the most toxic (Lalah *et al.*, 2019).

Medina *et al*. (2014) observed that at a particular interacting situations of two environmental stress factors, there are meaningful influences on the relative amounts of AFB_1 produced. These authors further stressed that one of the associated features of climate change that promote AFB_1 contamination in groundnut, and maize is drought stress in developing countries when water period occur, which might affect their nutritional values. According to Kos *et al*. (2013) prolonged hot and dry weather of 2012 caused AFs contamination of 69% of samples examined. Doboyi *et al*. (2013), as well revealed that climate change could lead to increased AFs contamination. Some reports have also implicated few cases of AFs contamination due to climate change factors (Magan *et al*., 2011). AFB_1 contamination could be stimulated under drought stress at 37^0C and 630 and 1000 ppm CO_2 exposure (Medina *et al*., 2014). Study also predicted that, on a global scale, pests and diseases are moving to the poles at the rate of 3-5 km / year (Bebber *et al*., 2013). This implies that more pest multiplication rates which could cause more harm and promote more infestation of *A. flavus* and contamination with AFs. History have also proved that with an increase in ambient temperature and decrease in rainfall, there can be increase in AFs contamination of peanut in Australia (Medina *et al*., 2014). These authors also noted Africa and Asia as risk regions, where AFs contamination could increase as a result of climate change conditions and a threat to foods / livestock feeds. Availability of water and temperature are known to influence life cycle of mycotoxigenic fungi and mycotoxin production (Sanchis and Magan; Magan Alched, 2007). AFs growth and toxin production could be enhanced by ecological conditions of water available and temperature, for instance, increased temperature (37^0C and water stress (0.95, 0.90 $_{aw}$). The mode of transportation, geographic origin, and the area where the feedstuff is stored, and length of storage in conjunction with certain climate conditions may affect aflatoxins concentration (Peterson and Lima, 2010; Donald *et al*., 2017). Since, climate change could lead to completive interactions among some terophilic fungi during dry and hot periods which could make secondary metabolites to increase, resulting to aflatoxins contamination of stable foods (Leong *et al*., 2010). Thus, there is need to periodically survey and re-verify the level of AFB_1 contamination of Nigerian GNC. Therefore, this study was designed to provide reliable data on the level of AFB_1 contamination of the Nigerian GNC from the six geopolitical zones of Nigeria.

MATERIALS AND METHODS

Preparation of GNC samples for aflatoxin B_1 quantification

The samples collected were prepared according to the manufacturer's (AgraQuant® Aflatoxin B_1 Assay (2-50 ppb) Competitive ELISA guidelines. The following procedures were followed:

i. Representative samples (20 grams) of GNC were put in conical flasks labelled according to the sampling location. The sample was milled so that 95% was able to pass through a 20-mesh screen and thoroughly mixed (homogeneous).
ii. 25 ml of 70% methanol extraction solution (70/30 (v/v) methanol/water) was added to the ground sample and the jar was sealed. Five (5) g of the ground GNC sample was measured using a sensitive scale that can measure in grams.
iii. It was blended for 3 minutes.
iv. Samples were allowed to settle, filtered the top layer of extract through a Whatman No 1 filter paper and the filtrate was collected. Proceeded to the test procedure. Note**:** extracts were allowed to have a pH of 6 – 8 preventing excessive alkaline or acidic condition which might affect the test result, therefore was adjusted before testing.
v. The filtrate was diluted in ratio 1: 2 with the assay buffer provided. Note: the sample in the filtrate served as the antigen.

Quantification of aflatoxin B_1 in GNC samples

The concentration of aflatoxin B_1 was analyzed by a competitive Enzyme-Linked Immunosorbent Assay (ELISA), which is based on an antigen-antibody reaction. For the enumeration, extracted samples were diluted into dilution wells by adding 200 ml of conjugate solution (provided with the kit) with 100 ml of extracted samples. After proper mixing, 100 ml conjugate mixed extract samples were transferred into antibody-coated wells and incubated for 15 minutes at room temperature. Following incubation, the wells were washed 5 times with deionized water (provided with the kit) and later kept dry. Then 100 ml substrate solution was pipetted into the antibody-coated wells and incubated at room temperature for another 5 minutes. Then, 100 ml stop solution (provided with the kit) was added into antibody-coated wells which changed the colour of the solution from blue to yellow. Finally, photometric measurement of aflatoxin B_1 was done by putting the antibody-coated wells in an ELISA aflatoxin B_1 reader (Chromate Plate Reader-4300 / USA) at 405nm, 450 nm and 630nm.

Calculation

To calculate the sample concentration, the curve had been obtained according formula used to calculate the %absorbance. The concentration of AFB_1 was calculated from the calibrated curve and software of the ELIZA machine directly.

Statistical analysis

Data collected from ELIZA were analyzed by the statistical analysis of variance (ANOVA) using the SPSS statistical package version 16.0.

RESULTS

Table 1 shows the AFB_1 contamination levels of the Nigerian GNC samples from the six geopolitical zones of Nigeria. In the rainy season, there were highest (450.00, 500.00 and 620.00 ppb) AFB_1 contamination levels among the samples of Nigerian GNC collected from the three Southern zones, compared to the three Northern zones (220.00, 190.00 and 241.00 ppb). However, during the dry season highest (300.00, 300.00 and 320.00 ppb) AFB_1 contamination levels were reported in samples from South-South (S-W), South-East (S-E) and

S-S respectively. While the highest values (189.00, 162.00 and 235.00 ppb) AFB_1 contamination levels were obtained in samples from North-West (N-W), N-E and North-Central (N-C) respectively. Specifically, the highest mean AFB_1 contamination was recorded in the South-South during the dry season (171.00 ppb), the rainy season (358.00 ppb), and in both seasons (264.50 ppb); while the least mean level of AFB_1 contamination was recorded in the North-East during the dry season (80.18 ppb), in the rainy season (97.25 ppb), and in both seasons (88.72 ppb).

Table 1: Aflatoxin B_1 Level (ppb) of GNC from the Six Geopolitical Zones

	Season								Both	
	Dry				Rainy					
Geopolitical zone	Lowest	Highest	Mean	CV	Lowest	Highest	Mean	CV	Mean	CV
North-west	ND	189.00	95.88	1.33	12.00	220.00	116.00	1.45	105.94	1.39
North –east	ND	162.00	80.18	1.43	4.50	190.00	97.25	1.48	88.72	1.45
North-central	ND	235.00	124.07	1.34	22.00	241.00	131.50	1.42	127.79	1.38
South-west	1.80	300.00	140.19	1.50	61.00	450.00	255.50	1.38	197.85	1.44
South-east	3.00	300.00	151.50	1.39	65.00	500.00	282.50	1.38	217.00	1.39
South-south	22.00	320.00	171.00	1.23	96.00	620.00	358.00	1.37	264.50	1.30
Mean	4.47	188.32	100.59	1.29	43.42	370.17	206.79	1.40	153.69	1.34
CV	1.94	0.36	0.34	3.28	0.83	0.48	0.65	0.87	0.50	2.07
N	10	10			10	10			20	

ND: Not detected; CV: Coefficient of variation; N: Numbers of samples; ppb: Part per billion
Source: Field survey 2018

production. Therefore, transportation process and storage techniques may also be among the factors that contributed to the relatively higher levels of AFB_1 contamination of Nigerian GNC in the Southern zones of Nigeria (Abass *et al*., 2017). Since, climatic and storage conditions play vital roles in the growth of aflatoxin B_1 producing fungi (Mutegi *et al*., 2013).

CONCLUSION

Generally, the study established that the AFB_1 contamination of Nigerian GNC was higher in the Southern zones compared to the Northern zones of Nigeria. This is evident that AFB_1 contamination levels in most especially Southern Nigeria requires more attention. It is suggested that extension officers should take up the task of adequately creating the awareness of AFB_1 contamination of GNC, its possible effect on the value of the GNC and well-being of poultry as well as its economic effect among the farmers. Also, levels of AFB_1 contamination of Nigerian GNC can be reduced by intensifying surveillance at various points of GNC production, and ensure that infected groundnut seeds are not used in the production of GNC.

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Personal hygiene as food safety measures: the perception of street-food and snacks vendors in Dutsin-Ma, Katsina Sate, Nigeria.

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ABSTRACT

The World Health Organization recognized foodborne illnesses and occurrences as a foremost public health threat globally. Personal hygiene practices are keys to making street food and snacks safe to consume and the perception its handlers on personal hygienic practices rank high amongst the major concerns that may potentially lead towards food not being safe. This study therefore primarily examined the perception of the street food and snacks vendors in the study area on personal hygiene viz-a-viz safe food for the consumers. Using a 2-stage sampling procedure, 60 respondents were selected and relevant information collected from them using a well-structured questionnaire. Data collected were analyzed using simple descriptive statistics. The results shows that majority (53%) of the respondents were not registered with NAFDAC; most of them (53%) are engaged in the street food and snacks business full time. About 70% of the respondents sell only snacks and most of them are new entrants into the business with less than 5years experience. Furthermore, the study revealed that 45% of them do not really see washing of hands as a compulsory practice and 67% of the respondents do not agree with the use of hand gloves in selling their snacks. The study concluded that the respondents have poor perception about personal hygiene as a food safety measure in street food and snacks selling business. The study therefore recommends that the relevant agencies beam their light on the study area to educate the stakeholders in the sector.

Key words: Food-Safety, Hygiene, Perception Snacks

INTRODUCTION

World Health Organization (WHO) recognized foodborne illnesses and occurrences as a foremost public health threat globally of the 21st Century (World Health Organization (WHO), 2015). Unsafe food handling increasingly results in bacterial food poisoning cases in Saudi Arabia (El Sheikha, 2015). It is therefore imperative that safe foods are consumed. Food safety is a vital issue both in developed and developing countries; given that food borne illnesses contribute to millions of illnesses and thousands of deaths annually (Pilling, et al., 2008). A vital aspect of food safety is good knowledge and right perception of good personal hygiene measures. This is more critical for those who handle food and or snacks consumed by the public. Snacks and street foods or fast foods are "ready-to–eat" foods and beverages that are prepared and sold by vendors and hawkers especially in the street and other similar public places (Food and Agricultural Organization, 1997). Preparing and selling food on the streets provide a constant income for millions of unenlightened people in fact; approximately 2.5 billion people around the world consume street-food (snacks) every day (Food and Agricultural Organization (FAO), 2011). Personal hygiene according to (Rahman, Tosepu, Karimuna, Yusran, & Junaid, 2018) is a way of caring for humans to maintain their health. Maintenance of individual hygiene is needed for individual comfort, security, and health. It is also very important that public food handlers keep basic rules of hygiene so to ensure the safety of their customers. The perception of the respondents about personal hygienic practices of food handlers' rank amongst the major concerns that may potentially lead towards food not being safe. In this study, some basic occupational traits of street food and snacks vendors and their perception of personal hygiene as food safety measures in the study area was assessed.

METHODOLOGY

The study was carried out in Dutsin-Ma town, the Dutsin-Ma Local Government Area headquarters which hosts the Federal University Dutsin-Ma as well as the Isah Kaita College of Education with several secondary and primary schools as well as other government and private agencies. The Local Government lies between latitude 120 17.00ʹN to 120 17.84ʹN and longitude 0070 26′ E. It has a land size of about 552.323km^2. Although the indigenes are predominantly crop farmers, cattle farmers and traders, the town plays hosts to thousands of students and workers that are not indigenes. The community comprise of Hausa and Fulani ethnic groups while Islam is the predominant religion.

A two-stage sampling procedure was used to select 60 street food and snack vendors interviewed for the study. In the first stage, Purposive selection of six (6) locations where street food and snacks vendors were concentrated (Wednesday market road, FUDMA take-off site environs, Hospital road, Wednesday market, Old market and Gangere Motor Park) was made. The street food and snacks vendors were counted to be 505. In the second stage, 60 samples were proportionately selected and used as samples for the study. The 60 sample size was selected using raosoft calculator using 10% margin error, 90% confidence level, and 50% response distribution (www.raosoftcalculator/samplesize.html). A well-structured questionnaire was used to collect relevant information from the respondents. The data was analyzed using simple descriptive statistics.

RESULTS AND DISCUSSION

Basic occupational traits of the vendors of the street food and snacks vendors in the study area

Basic occupational information of the vendors is shown in Table 1. Majority of street food vendors (93%) are not registered with National Food and Drug Administration and Control (NAFDAC). However, seven percent (7%) vendors are registered members with the agency. This implies that there is probably no monitoring of what the vendors are selling to the public in the study areas. Majority (53%) of the responses are full time street food and snacks vendors while 47% are part-time with other things they do for a living. A good majority (70%) of the respondents sells snacks only, 25% sells food only while 5% sells both food and snacks. This probably is because the study area is a community dominated with many students of tertiary institutions who prefers fast food most of the times. About 25% of the street and food vendors have between 6 and 16 years' experience while 12% have between 17 and 22 years' experience. Most of the respondents have less than 5 years' experience. This might be due to the fact that most of the respondents are also young. Only 8% have years of experience greater than 22 year.

Table 1: Basic occupational traits of the street-food and snacks vendors in the study area

Characteristics	**Frequency (%)**	**Percentage (%)**
Registered under NAFDAC		
Yes	4	7
No	56	93
Occupation Type		
Full Time	28	47
Part Time	32	53
category of item sold		
Snacks only	42	70
Food only	15	25
Food and Snacks	3	5
Experience (Years)		
< 5	33	55
6-10	14	23
11-16	1	2
17-22	7	12
> 22	5	8
Total	**60**	**100**

Source: Field Survey, 2021

Level of perception of food safety measures among the street food and snacks vendors in the study area

The respondents were confronted with some basic personal hygiene measures and their perception on each were documented in table 2. The result revealed that only 33% of the food and snacks vendors strongly believed that hands should be washed before handling food items. Furthermore, 22% agreed to this assertion but 45% are careless about washing of hands. It shows that a good number of these vendors have poor perception about hand washing before and after food and snacks handling. According to (Abdalla, Abdalla, Suliman, & Bakhiet, 2009), hand washing is an important aspect of personal hygiene expected to be strictly adhered to by food and snacks vendors because the organisms such as *Salmonella typhi*, non-*typhi salomnella*, *Compylobacter* spp. and *E. coli* can survive on fingers tips and other surfaces for varying periods of time and some cases after hand washing. On the issue of washing of utensils, a good majority have a good perception to it as 38% and 50% of the respondents strongly agreed and agreed to it respectively. Those who are indifferent, those that disagreed and those who strongly disagreed to this assertion were 8%, 2% and 2% of the respondents respectively. The vendors' perception on covering of wounds during the process of handling food items is fair, about 75% of them agreed/strongly agreed to the assertion. On the issue of staying back at home, 26% of them did not see much need to that assertion. The vendors have a good perception about using clean containers for storing food items. According to Table 2 also, 84% of the respondent agreed that deteriorated food should be disposed properly. This implies that most of the respondents are not adding deteriorated food or snacks to newly prepared ones in order to maximize profit. Those who disagreed with this assertion are just 2% while 15% are indifferent. Covering of mouth/nose while sneezing is a hygienic practice that some people might take lightly. According to the result presented in Table 6, 7% disagreed on the need to practice it as food handlers while 48% said they are indifferent. This implies that more than 50% have the probability not to imbibe the practice. This definitely will expose consumers of snacks and food from such people to communicable diseases. From the result also, less than half of the respondents (46%) agreed with the assertion properly covering of food/snacks after preparation. Furthermore, 3% did not see the need for that practice while 51% are indifferent meaning that practicing it for them is by chance and not deliberate. From personal observation of the researcher during data collection, many food and snacks vendors do not cover their items properly.

Similarly, 10% of the food and snacks vendors never agreed to the need for the use of hand gloves/fork to pick food items. They probably see that as luxury and not needed. On the other hand, 57% are indifferent on the use of hand glove or fork implying that they will only use such by chance. On the vendors' consideration for the neatness of their selling points, the result in Table 2 shows that 65% of the respondents agreed that it is a very important factor to consider. On the other hand, 17% are indifferent while 18% out rightly disagreed on the need to consider the neatness of their selling points. This might be the reason why some of them as observed are located in indecent places selling snacks.

From the results discussed, it is obvious that the perception of the street food and snacks vendors in the study area is weak to make them serve safe foods to the consumers. Similar studies like (Wafa, Anushree , & Amit, 2018) highlighted poor knowledge of mothers in Saudi Arabia with regard to food handling and poor knowledge of food handling among women in Saudi Arabia was reported. (Farahat, El-Shafie, & Waly, 2015).

Table 2: Level of perception of food safety measures among the street food and snacks vendors in the study area

Safety Measure	*Level of perception				
	S.A	A	I	D	S.D
Hand washing before and after food preparation	20 (33)	13 (22)	27 (45)	0	0
Washing of utensils before and after use	23 (38)	30(50)	5(8)	1(2)	1(2)
Covering of wound properly during food/snacks preparation	19(32)	25(42)	14(23)	2(3)	0
Staying back at home when indisposed or sick	19(32)	25(42)	13(21)	3(5)	0
Using of good and clean containers for storing food/snacks after processing	21(35)	30(50)	9(15)	0	0
Properly disposing of deteriorated food/snacks	19(32)	31(51)	9(15)	1(2)	0

Covering of mouth/nose while sneezing/coughing	15(25)	13(22)	28(46)	4(7)	0
Covering of food/snacks after preparation	14(23)	14(23)	30(50)	2(4)	0
Use of hand gloves/fork for dispensing food	14(23)	6(10)	34(57)	6(10)	0
Neatness of selling point location	19(32)	20(33)	10(17)	11(18)	0

*Key: S.A=Strongly Agree; A=Agree; I=Indifferent; D=Disagree and S.D=Strongly Disagree.*Percentages in parenthesis*

Source: Field Survey, 2021

CONCLUSION AND RECOMMENDATION

Based on the findings of this study, it was concluded that the street food and snack vendors in the study area has poor perception about personal hygiene as a measure of food safety. It therefore recommends that the relevant agencies should pay attention to the sector in the study area to curb impending health consequences.

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Proximate analysis of some fruits sold in Abraka, Delta State, Nigeria

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ABSTRACT

The study was carried with a view to evaluating the proximate constituents of some fruits sold in Abraka, Delta State, Nigeria. Selected fruits were velvet tamarind (Dalium guineensis), soursop (Anona muricata), pineapple (Ananas comosus) and avocado (Persea americana). The fleshy parts were oven dried, blended and analysed. The results showed variations in the proximate content of the fruit species P. comosus has the highest moisture composition (86.76) followed by A. Muricata (75.00%) and P. Americana (67.87%) while D. guineensis had the least value (10.30) for moisture content. Ash was highest in A. muricata (3.43%) followed by D. guineensis (2.52%) and least in A. comosus (0.34%). Crude fibre was higher in A. comosus (7.00%) followed by P. americana (4.65%). Carbohydrate was significantly higher (P$\leq$0.05) in D.guineensis when compared with values recorded for A. comosus (9.87%). The study indicated that D. guineensis can be used as a source of protein as it could help in body building and cells repair. Fat is a good source of energy and a medium for dissolving vitamins A, B, C and K hence P. americana could be taken as a source of fat beside the fibre ash and other mineral contents. The study has confirmed the presence of numerous mineral chemicals and nutrients in the fruit studied hence, should be included in our daily diets for optimum body metabolism and maintenance of good health.

Key words: Fruits, proximate compounds, good health.

INTRODUCTION

Fruits are excellent sources of nutrients and are antioxidants packed. They are rich in vitamins, minerals, fibres, water and organic acids (Agbogidi, 2019). Dieticians have encouraged the eating of fruits to maintain good health and protection against heart diseases, cancer, kidney stones and type 2 diabetes (Ekpete and Edori, 2013). Fruits are also low in calories hence, useful in weight management (Li, 2008; Adeputu, 2009). Everyone including children need adequate fruits to stay healthy and for optimum body metabolism. Fruits are rich in carbohydrates, vitamins; A, B1, B2, C, and E, and minerals such as Ca, Mg, Zn, Fe, K, and other organic compounds and anti-nutrients (Panda, 2010; Terry, 2011). It is also common that fruits vary in their nutrient contents hence the need to assess the proximate analysis of some fruit species sold in Abraka, Delta State with a view to recommending the very nutrient rich ones to the rural populace of Abraka and its environs.

MATERIALS AND METHODS

Study area: The study was carried out in Abraka, Delta State. Abraka is located in Ethiope East Local Government Area of Delta State and is situated between latitude 5^0 45' and 5^0 5^{0}' N and longitude 6^0 and 6^0 15'E in an agglomeration of several communities that are aligned linearly along the New and Old Sapele-Agbor highway. The Abraka area is a typical coastal plain terrain, monotonously lowland and flat with a gentle slope towards the Ethiope River. The climate is equatorial, hot (23 to 37^0C) and humid (relative humidity, 50 to 70%). There is dry season from about November to February and a wet season that begins in March, peaks in July and October. Vegetation is rainforest, most of which has been decimated and replaced with farmlands and secondary forest (Efe and Aruegodor, 2003).

Collection of fruit samples: Selected fruits (velvet tamarind, soursop, pineapple and avocado) were purchased from Abraka main market. The fleshy parts were oven dried and blended to fine powder using mechanical blender. The samples were stored in clean polythene bags and taken to the laboratory for analysis of proximate composition.

Proximate analysis: Moisture contents was determined by the gravimetric method described by Kjeldahl method, total ash content was by the furnaces incineration gravimetric method following the procedure of James (1995) and AOAC (2003). Crude fibre was determined by the method of James (1995), crude fat was by solvent extraction gravimetric method described by Kirk and Sawyer (1980) and carbohydrate was determined using the method of James (1995).

Results obtained were subjected to one-way analysis of variance while the significant means were separated using SAS (2006). Stored in clean polyethylene bags and transferred to the laboratory for analysis of proximate contents.

RESULTS AND DISCUSSION

The scientific information of the fruit species used are described in Table 1.
Proximate composition of fruits sold in Abraka, Delta state, Nigeria is described in Table 2.

Table 1. Scientific information of the fruit species used

S/n	Common name	Scientific name	Family
1.	Velvet tamarind	*Dialium guineense* Willd	Fabaceae
2.	Sour sop	*Annona muricata* L	Annonaceae
3.	Pine apple	*Ananas comosus* L. (Mere)	Bromeliaceae
4.	Avocado	*Persea americana* Mill	Lauraceae

Table 2. Proximate composition of fruits sold in Abraka, Delta State

Fruits	Proximate composition %					
	Moisture	Ash	C.Fibre	C.Fat	C.Protein	C .Carbohydrates
D. guineensis	10.30d	2.52b	1.18c	5.66b	3.71a	77.79a
A. ***Muricata***	75.00b	3.43a	0.19d	3.25c	2.91b	15.41b
A. comosus	86.78a	0.34d	7.00a	0.26d	2.77c	9.87d
P. americana	67.87c	1.05c	4.65b	14.63a	2.76c	13.69c

Means with different letters in the same rows are significantly different at (P≤0.05) using the Duncan's Multiple Range Tests (DMRT).

The results showed variations in the proximate content of the fruit species *P. comosus* has the highest moisture composition (86.76%) followed by *A. muricata* (75.00%) and *P. Americana* (67.87%) while *D. guineensis* had the least value (10.30%) for moisture content. Ash was highest in *A. muricata* (3.43%) followed by *D. guineensis* (2.52%) and least in *A. comosus* (0.34%). Crude fibre was higher in A. comosus (7.00%) followed by *P.americana* (4.65%). Carbohydrate was significantly higher (P≤0.05) in *D.guineensis* when compared with values recorded for *A. comosus* (9.87%). The study indicated that D. *guineensis* (77.79%) can be used as a source of protein as it could help in body building and of cells repair. Fat is a good source of energy and a medium for dissolving vitamins A, B, C and K hence *P. Americana* could be taken as a source of fat beside the fibre ash and other mineral contents (Ganny, 2008). The high source of water in *A. comosus* is similar to the water content of paw paw (Aravind *et al*., 2013). Apart from its sweetness and high water contents, pineapple and some chemical composition that protects the kidney against kidney stones and excessive blood pressure (Ekpete and Edori, 2013).

CONCLUSION

The study has confirmed the presence of numerous mineral chemicals and nutrients in the fruit studied hence, should be included in our daily diets for optimum body metabolism and maintenance of good health.

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Preventive And Curative Control Of Postharvest Rot Of Root Crops With Plant Extract Combinations

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ABSTRACT
Postharvest fungal rot is one of the major constraints to sweet potato production. Combined methanolic extracts of *Allium sativum* and *Zingiber officinale* and *Allium sativum* and *Moringa oleifera* were evaluated for efficacy in inhibiting postharvest rot of sweetpotato using preventive and curative methods, with Mancozeb 80WP (0.2%) used as a positive control. The design was CRD with 3 replications. Data was analyzed using Analysis of Variance and differences between means were compared using Duncan's Multiple Range Test (P=0.05). The result showed that combined methanolic extracts of *A. sativum* and *Z. officinale* or *M. oleifera* were effective in reducing rot of sweet potato when applied in both preventive and curative methods. Mancozed, *Allium sativum/Zingiber officinale* extract combination and *Allium sativum/Moringa oleifera* extract combination exhibited rot inhibitions that ranged from 85.9333 ± 0.4099 to 100%, 39.4133 ±0.3099 to 97.8367±0.0876 % and 31.9400±0.0971 to 99.0467 ±0.5374% respectively. There was significant (P=0.05) interaction between the control methods and treatments for all the pathogens. Control treatments were more effective when applied as a preventive measure than in curative form, shown by a significantly higher rot inhibition exhibited in the sweet potatoes pre-inoculated and pre storage treatment tests in both plant extract combinations than those of post-inoculated treatments in 14 days of storage at room temperature. Therefore, combined methanolic extracts of *Allium sativum* and *Zingiber officinale* or *Allium sativum* and *Moringa oleifera* holds promising prospect for use in the development of novel bio-fungicide for management of postharvest rot of sweet potatoes.

Keywords: *Zingiber Officinale*, In vivo, Postharvest Rot, Sweet Potato, Extract Combinations, Control

INTRODUCTION
Sweet potato roots are susceptible to many microbial infections at different stages including field stages including field, harvest, storage (if they are not properly harvested and stored) and marketing stages (Alum *et al*., 2019a). In a previous study, three hundred and fifty-two fungi were isolated from 200 sweet potato samples from Ebonyi State. Seven species of fungi including

Botrydiplodiae theobromae, Rhizopus oryzae, A. niger, A. flavus, F. solani, P. expansum and *A. awamori* have been implicated with sweet potato rot causation in Ebonyi State; inciting four categories of rot (dry rot, soft rot, java black rot and blue green mold) (Alum *et al.*, 2019a). Fungi rot on roots of sweet potato significantly (P=0.05) depletes carbohydrates, crude fibre and moisture contents (Alum *et al*, 2019b).

Due to the negative economic importance of the fungal pathogens, their control on sweet potato is needed. Given the drawbacks associated with the orthodox rot control approaches based on chemicals, focus in recent times, has shifted toward exploitation of plant extracts as novel fungicides in plant protection (Akueshi *et al.*2002; Okigbo and Nmeka, 2005). Two plant extract combinations (Combination of *Allium sativum* and *Zingiber officinale* extracts and combination of *Allium sativum* and *Moringa oleifera* extracts have been reported to inhibit mycelia growth of postharvest rot-inducing fungi in vitro with no antagonism {Alum and Umeh, 2020). According to Ranasinghe *et al.* (2002), the antimicrobial activity of plant extracts that is observed in *in-vitro* conditions is quite different from its effect in complex food systems. In most cases, antimicrobial activity is decreased due to interactions with food components (Ranasinghe *et al.* 2002).

Despite this recognition, there was however, paucity of information on the ability of the said plant extract combinations (Combinations of *Allium sativum* and *Zingiber officinale* and *Allium sativum* and *Moringa oleifera*) to inhibit sweet potato fungal rot in vivo. Against this back drop, the present study was therefore aimed at testing the sweet potato postharvest rot inhibitory capability of combinations of *Allium sativum* and *Zingiber officinale* and *Allium sativum* and *Moringa oleifera*.

MATERIALS AND METHODS

To determine if the antimicrobial-producing plant extracts combinations have a potential application in bio-preservation of sweet potato roots, a food trial was undertaken using the methods of Tijjani *et al.* (2013). Fresh, healthy sweet potato roots of the Tupiaochi cultivar were purchased from Ebonyi sweet potato farmers and used for the evaluation. Seven fungi including *Botryodiplodia theobromae, Fusarium solani, Aspergillus flavus, Aspergillus niger, Penicillium expansum, Rhizopus oryzae* and *Aspergillus awamori* isolated from symptomatic sweet potato roots and confirmed responsible for postharvest spoilage of sweet potato in Ebonyi State in a previous study (Alum *et al.*, 2019a) were employed in the study. The treatments included negative control (sterile distilled water), positive control (Mancozeb), *A. sativum* and *M. oleifera* extract combination and *A. sativum* and *Z. officinale* extract combination. Evaluation was done via two methods- preventive and the curative methods. This evaluation was based on the method of Tijjani *et al.* (2013) with modification in the quantity of applied inocula (3 x 104 sporangia/ml of sterile distilled water according to Suleiman and Emua (2009). The negative control set up consisted non-treated, wounded and inoculated while the positive control setup was sweet potato roots treated with Mancozeb 80WP (0.2%). The inoculated sweetpotato roots were incubated at room temperature (28 ± 2^{o}C) for 14 days. After the incubation period, the tubers were incised horizontally with sterile knife. The length of rotted portion from each hole was measured over the total surface length with a metre rule and fungitoxicity determined in form of percentage growth inhibition which was calculated according to the formula of Okigbo and Nmeka (2005)

$$\text{Growth inhibition (\%)} = \frac{(LC - LT) \times 100}{LC}$$

Where: LC = average length of unrotted portion of control and LT = average length of unrotted portion with treatment.

The Experimental set up was Completely Randomized Design with 3 replications. All data were analyzed by Analysis of Variance (ANOVA) using SPSS 20.0 Version. Differences between the treatment means were tested using Duncan's New Multiple Range Test. Significance was considered at P=0.05.

Results and Discussion

Results on the effect that mancozeb and the combined plant extracts exhibited against the postharvest rot caused by the test fungi on sweet potatoes is presented in Table 1. The results showed that all treatments significantly inhibited rot development by all the fungi compared to the negative control (non-treated, wounded and inoculated root) that gave zero inhibition. Furthermore, the results showed significant (P=0.05) interaction between method (preventive and curative) and treatments for all the pathogens. Inhibition of rot exhibited by all the treatments was significantly (P=0.05) higher with the preventive method than with the curative method across all postharvest pathogens except in only *A. niger* where percentage inhibition (100%) recorded by mancozeb was the same in both preventive and curative methods. This lends credence to the report that effective disease management strategy is proactive and prophylactic rather than curative (Amaeze *et al.*, 2009). Mancozed, *Allium sativum/Zingiber officinale* extract combination and *Allium sativum/Moringa oleifera* extract combination exhibited rot inhibitions that ranged from 85.9333 ± 0.4099 to 100%, 39.4133 ±0.3099 to 97.8367±0.0876 % and 31.9400±0.0971 to 99.0467 ±0.5374% respectively. The highest percentage rot inhibition (100 ± 0.00%) was recorded by mancozeb against *A. niger*; however, inhibition of *B. theobromae* by mancozeb (88.8267±0.0807%) was significantly lower than that of *Allium sativum/Zingiber officinale* extract combination (91.1233 ±0.1510%) on the same pathogen.

The in vivo effects of the single plant extracts was not evaluated in this study, therefore there were no values with which to compare the in vivo effects of the combined extracts so as to ascertain potentials for synergism or otherwise. However, when comparing the in vivo effects of combined plant extracts to them in vitro effects as well as the in vivo effects of Mancozeb, a parallel may be drawn between results from the in vivo study and those achieved by the in vitro study, in that the results of the in vivo effects showed a similar trend (above 50% inhibition) with those in the in vitro assay.

CONCLUSION

Combinations of *A. sativum /Z. officinale extracts* and *A. sativum/ M. oleifera* extracts hold promising prospect for use in the development of novel biofungicide for management of postharvest fungi/rot of sweet potatoes. For optimum results however, the treatment regimens should be applied as a prophylactic measure. The plant extract combinations however, need to be subjected to further evaluations.

Table 1: Comparative Evaluation of In Vivo Inhibitory Effect of Plant Extract Combinations on Postharvest Rot on Sweet Potato

Fungi	Treatments/ Percentage Inhibition					
	Treatment Method	**Positive Control**	**ASZO**	**ASMO**	**Total**	**Negative Control**
B. theobromae	PVT	^{b}88.8267 ±0.8087$_{b}$	^{a}91.1233 ±0.1510$_{a}$	^{d}70.1167 ±0.1692$_{c}$	83.3556 ±3.3350	0.00

	CRT	^{c}86.6533 ±0.3267$_{a}$	^{e}67.7267 ±0.3670$_{b}$	^{f}65.6967 ±0.4489$_{c}$	73.3589 ±3.3420	0.00
R. oryzae	PVT	^{b}91.1233 ±0.1510$_{a}$	^{c}53.2267 ±0.1746$_{b}$	^{d}49.9667 ±0.1052$_{c}$	64.9589 ±6.7100	0.00
	CRT	^{a}90.0867 ± 0.0867$_{a}$	^{e}39.4133 ±0.3099$_{c}$	^{d}48.8600 ±0.5311$_{b}$	59.4533 ±7.7808	0.00
F. solani	PVT	^{a}97.4333 ±0.2963$_{a}$	^{b}85.1900 ±0.4356$_{b}$	^{d}35.3133 ±0.1878$_{c}$	72.6458 ±9.5003	0.00
	CRT	^{a}97.4167 ±0.3950$_{a}$	^{c}64.6033 ±0.3967$_{b}$	^{d}31.9400 ±0.0971$_{c}$	64.6533 ±9.4520	0.00
A. niger	PVT	^{a}100 ±0.00$_{a}$	^{b}83.3767 ±0.3232$_{b}$	^{c}81.9500 ±0.1266$_{c}$	88.4423 ±2.8981	0.00
	CRT	^{a}100 ±0.00$_{a}$	^{e}67.9433 ±0.5904$_{c}$	^{d}80.30 ±0.3881$_{b}$	82.7478 ±4.6717	0.00
P. expansum	PVT	^{a}100 ± 0.00$_{a}$	^{c}97.8367 ±0.0876$_{b}$	^{b}99.0467 ±0.5374$_{a}$	98.9611 ±0.3502	0.00
	CRT	^{c}98.0400 ±0.3469$_{a}$	^{d}74.0200 ±0.0814$_{b}$	^{d}73.3567 ±0.3273$_{b}$	81.8056 ±4.0621	0.00
A. awamori	PVT	^{a}94.8333 ±0.6880$_{a}$	^{c}64.1367 ±0.5216$_{b}$	^{e}53.0600 ±0.35346$_{c}$	70.6767 ±6.2530	0.00
	CRT	^{b}89.5400 ±0.2573$_{a}$	^{d}57.2800 ±0.6248$_{b}$	^{f}44.9400 ±0.0600$_{c}$	63.9200 ±6.6512	0.00
A. flavus	PVT	^{a}86.9967 ±0.01453$_{a}$	^{b}77.1400 ±0.59408$_{b}$	^{d}50.7467 ±0.3047$_{c}$	71.6278 ±5.4141	0.00
	CRT	^{a}85.9333 ±0.4099$_{a}$	^{c}61.8600 ±0.5816$_{b}$	^{e}48.7467 ±0.3307$_{c}$	65.5133 ±5.4493	0.00

Data represent average mean of three replicates ± S.E. Treatment and Method means with different subscripts and superscripts respectively, are significantly different; PVT= Preventive; CRT= Curative; ASZO= *A. sativum* and *Z. officinale* extract combination; ASMO= *A. sativum* and *M. oleifera* extract combination

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Sub-Theme A: Agricultural business and policy resources, Agricultural Extension, Administration, communication and rural development and Gender mainstreaming strategies in agriculture
(Cont'd)

Food Insecurity and Coping Strategies Among Female Headed Households in Abia State, Nigeria

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ABSTRACT
This study analyzed food insecurity and coping strategies among female headed households in Abia State, Nigeria. 0ne hundred and twenty (120) female headed households were randomly selected from the study area using multi stage random sampling techniques. Primary data were obtained using structured questionnaire. The objectives of the study were analyzed using percentages responses and probit regression model analysis. The result obtained showed that most of the female headed households were aged, high literacy level (87.5%) and moderate household size (1 – 6 persons). Also, the household size and level of education were the determinant factors to attainment of food security by female household. The result also indicated that the most common coping strategies for food insecurity were engagement in off-farm income (68.33%), while the least was migration (20%). There is need to enhance farmers' access to adult education and labour-saving devices at subsidized cost.
Keyword; Food insecurity, Coping strategies, female headed households, Abia State, Nigeria

INTRODUCTION
Agriculture is Nigeria, single largest industry apart from oil sector with smallholder farmers being in the helm of the affairs, just like many parts of the world (IFAD, 2013). In, Nigeria and many countries in sub-Saharan Africa, women constitute about 70 – 80% of the farming population, and play important roles in food and agriculture (World Bank, 2013). Despite the efforts of this farming class in enhancing food sufficiency to the world population, but in many developing countries, this farmers have limited access to land; credit facilities farm input training and advice, technology and crop insurance among other things. The worse-off among the women is female headed households, who run their own farms without male assistance. (Ume, *et al;* 2018). Studies show that compare to the male counterpart, this class of household is poorer and continue to grow due to socioeconomic characteristics and among others (Sepahvand, 2019). Studies show that when women farmers have the same access to productive resources as men, they can increase yields by 20 to 30 percent (Sepahvand, 2019). In developing countries, this could potentially increase overall agricultural output by 2.5 to 4 percent and lift 100 to 150 million people (IFAD, 2012).
In Nigeria, successive governments have instituted varied programmes to cushion the effects of food insecurity through enhancing the farmers' access to improved farm inputs and tools and technical support, traditional thrift and saving and value-added access to credit as a way of alleviating poverty (Dauda, 2014). However, the success of the poverty alleviation programmes as asserted by World Bank (2013) had been hampered by inadequate financial support, corruption, inability to board the essential population and human resources, war, and community dissension. In effect, food insecurity continually spreading like wide fire and, studies revealed that the household structure both in urban and rural areas have devised several coping strategies in averting maximally

food insecurity ((Burvinic and Gupha, 2013) This study tends to bridge the research gap in the study area, as regards the determinant factors influencing the attainment of food security and coping strategies adopted by the female headed households.

MATERIAL AND METHODS

The study was carried out in Abia state. Abia State lies between latitudes $04^0$45'and 04º41' North and longitudes $7^0$5' and $08^0$04' East. It occupies a total land area of 6,420square kilometer with a population of approximately 284.104 million people (NPC, 2006). It has annual rainfall of 1800-2000mm and temperature range of 22^0C-38^0C during the year. The people in the area are predominantly farmers, although engage in other economic activities.120 female headed households were randomly selected from 12 Local Government Area out of 17 that made up the state for detailed study. Structured questionnaire and oral interview were used to collect the data. Percentages responses and probit model analysis were used to address the objectives of the study.

Model Specification

Probit Analysis

The probit analysis was used to capture the determinants of poverty among the rural farming household. The model can be stated as:

$1*_i = \beta Tx_i + ei$ ………………………………………………………………… (1)

$Y_i = 0$ if $1*_i = T$ ……………………………………………………………… (2)

$Y_i = 1$ if $1*_i > T$……………………………………………………………… (3)

Where Yi represents a limited dependent variable which simultaneously measures the level of poverty and the level of is an underlying latent variable that indexes adoption. T is an observed threshold level, X is the vector of independent variables affecting poverty level, β^T is a vector of parameters to be estimated, and ei is the error term. If the non-observed value of 1* is greater than T, the observed variable Ti becomes a continues function of the independent variables and O otherwise. The model is specified in an implicit form as follows:

$Y = F (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8 + ei)$

Y = Food security status (Secure; 1; insecure; 0. X_1= Age of the respondents(years), X_2= Off- farm income (N), X_3 = Educational Level (Years), X_4 = Farming experience(Years), X_5= Household Size (No).

RESULTS AND DISCUSSION

Table 1: Socioeconomic Characteristics of Female Household Heads

Variable		Frequency	Percentage
Age (years)			
25-50		32	26.67
51 -76		68	56.67
77 -100		20	16.67
Mean	**52**		
Household Size (number of persons)			
1-6		65	54.17
7-12		50	41.67
13-18		5	4.17
Mean	6		
Education			
No formal education		15	12.5
Primary		90	75
Secondary		10	8.33
Tertiary		5	4.167
Mean	**7**		
Farming experience (years)			
1 – 10		60	
11 – 21		40	50
22 - 32		20	33.3
Mean		12.7	16.67
Off- Farm Income			

Yes	100	83.3
No	20	16.7

Source: Field Survey, 2021

Table 1 shows that the mean age of the respondents was 52 years old. This implies that most of the female headed households have dependents and could adopt technologies to enhance their food security status (Burvinic and Gupha, 2013). Also, 54.17% of the respondents had household size of 1- 6 persons, followed by 41.67%; 7- 12 persons, while the least 4.17%; 13-18 persons. Amber, *et al;* 2014) reported that large household size that is dependent population tends to exert more pressure on consumption than the labour it contributes to production. Besides, 12.5% of the respondents had no formal education, 87.5% had formal education. Educational status of the farmer makes her to be more objective in evaluating innovations which could positively influence their food secure status through attainment of high productions targets (World Bank, 2013). Table I moreover shows that 83.3% of the respondents had years of farming experience above 10 years, while 16.7% had less than 11 years. The average year of experience was 27. This implies that most of the female headed households are well experienced in farming In order to diversify her production and minimize risks of food shortages (FAO, 2019). Furthermore, majority (83.3%) of the sampled population engaged in off farm income and only 16.7% do not. Off -farm income could be used for family consumption and to offset market risks (World Bank, 2013).

The result in Table 2 indicated that the most common coping strategy of food insecurity in the study area was employment in off- farm activities.

Table 2: Distribution of female household heads according to coping strategies adopted by

Strategy	Frequency	Percentage
Decrease in meal frequency	78	120
Sale of farm assets and land	45	37.5
Over reliance on remittance	74	61.67
Withdrawal of children from school	38	31.67
Reduction in other expenditure	50	41.67
Off farm income	96	80
Food aid	65	54.27
Migration	24	20

*** Multiple responses**

Source: Field Survey, 2021

Literatures show that reasons for this observed income diversification include declining farm incomes and the desire to insure against agricultural production and market risks (Ogbonna, 2018). Also, female household, in particular pulled into the off-farm sector, especially when returns to off-farm employment are higher or less risky than in agriculture, resulting in "demand-pull" diversification. The result also showed that the least, (20%) adopted coping strategy was migration. This strategy is common among herders in the far northern part of Nigeria, who are often confronted with scarcity of fodder and water during certain periods of the year. To that effect migrate southwards where these resources are abundance to caution the effect (Ume, *et al*, 2018).

Table 3: Determinant factors influencing the attainment of food security.

Variable	**Coefficient**	**Standard Error**	**Z – ration**	p>IZI
Constant	4.653	1.234	3.771***	0.240
Age	- 4.654	2.230	- 2.086*	0.104
Off farm income	0.456	0.362	1.260	0.005
Educational Level	4.074	1.045	3.897***	0.213
Farming Experience	1.006	1.027	0.9795	0.132
Household size	3.132	1.112	2.817**	0.027

Log likelihood	-117.4375
Wald chi2	(12) 34.05
Pseudo R2	0.1323

Cases predicted correctly (%) 734.4

Source: Field Survey, 2021,

****, **, * Significant at 1.0%, 5.0% and 10.0% levels respectively*

The coefficient of the age of the female headed household was positive and significant at 5% probability level. This implies that as age of the household advances, there is likelihood of decrease in being food secure especially where they have many dependent populations. Furthermore, as expected, the coefficient of level of education of the respondents had positive relationship with food security attainment and significant at 1% alpha level. This could be attributed to the fact that educated female headed households have the likelihood of attaining improved financial resources, which in turns raises their farm productive capacity (Ume, *et al*; 2018). Moreover, the coefficient of the female headed household size was positive and in line to apriori knowledge and significant at 5% probability level. The sign identity of the variable could be linked to the use of members of the household in farming for increased output which turn out for higher income. Nevertheless, Amber; *et al*; (2013) found negative relationship between household size and food security. They were of the view that increase in one additional member per head, generally reduces income per head, expenditure per head, and per consumption increases with a rise in household members.

CONCLUSION AND RECOMMENDATION

Based on the finding, the following conclusions were deduced; First, most of the respondents were aged, educated, had moderate household size and well experienced. Second, the educational level of the farmer and household size were the determinant factors to attainment of food security.

Based on the conclusion, the following recommendations were proffered

Government and non-governmental organizations (NGO) should intensify efforts on importance of family planning and advocate for small family size. As well, Farmers with large household size should be encouraged to be actively involved in adoption of technologies since large household size would provide the much needed labour requirements in food production activities at low cost, compared to hired labour. Also, there is need to strengthen the current policies on education such as the universal basic education, adult education and nomadic education. Furthermore, policies aimed at improving farmer's access to education through aggressive awareness campaign and mass mobilization are needed.

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Assessment of Deal-breaker traits and willingness to buy Preferred improved cassava seed by farmers in southern Nigeria

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ABSTRACT

To understand the varietal traits that attract cassava seed users and their willingness to buy the cassava varieties that possess the desired traits, a study was conducted in four selected states in southeast and south-south geopolitical zones of Nigeria where the activities of Building a Sustainable and Integrated Cassava Seed System (BASICS Project) is currently going on. The study adopted a combination of purposive and random sampling techniques to select 44 cassava farmers who have patronized the cassava seed entrepreneurs. Data obtained were subjected to descriptive statistics and probit regression analysis. Results of the study revealed three distinct trait categories that attracted the interest of the users. These categories include: Agronomic traits, product characteristics and marketability traits. Also, the probit regression output shows that farmers who planted local varieties previously were more likely to be willing to buy improved cassava varieties. Also, there is a varietal preference for TME 419 due to its high starch content and whitish colour including high dry matter content. It was therefore recommended that the identified traits should guide breeders in further varietal developments and the preferred variety (TME 419) should be massively multiplied and distributed to ensure that farmers have access to it at all times.

Key words: Cassava, seed, improved, varieties, farmer, preferred, trait

INTRODUCTION

Cassava is one of the important tropical root crops in Nigeria and Africa as a whole, considering that over 30 million Nigerian farmers, traders and processors are engaged in cassava value chains and agribusiness. Undoubtedly, Nigeria is the world's largest producers of the crop (FAO, 2020). Despite these achievements, cassava production is characterized by over 80% of smallholder farming outlay and dominant use of old and local varieties with traditional production technologies. These account for low yields experienced by the farmers.

National Root Crops Research Institute (NRCRI) Umudike and International Institute for Tropical Agriculture (IITA) Ibadan have developed varieties to meet the needs of the end users and increase demand. Such traits as high dry matter, high yielding, disease resistant, early maturing, high beta carotene content etc., constitute the quality demanded by the farmers. However, quality content of these traits differs according to variety, therefore will form a major consideration for the farmer to buy such variety. Before now, Teeken et al (2018) had opined that Nigerian cassava breeding programs prioritize traits in setting breeding agenda so as to impact the largest possible number of people through improved varieties. Furthermore, IITA (2021) reported that improved cassava varieties have been subjected to years of preference studies with rural women who plant, process and eat cassava. These varieties resist pests like cassava mosaic disease (CMD), have the right color and texture when prepared as meals.

Willingness to buy certified improved cassava seed is a measure of the ability and preparedness of a farmer or user to exchange a commodity with money payment due to certain accepted criteria that the variety possesses. Certainly, for a farmer to be willing to pay for a preferred variety, his or her perception of the seed should be better than what the farmer is already using and have the ability to give a positive return on investment. The expectation is influenced by quality traits of the variety that meet the criteria for selection by the farmer and at an affordable price. Deal breaker traits are those attributes (phenotypical and genotypical) of a cassava variety that qualifies it for acceptability by the farmer and end users. Such traits include agronomic, processing and marketability qualities of the variety that distinguishes it from other varieties and thus attracts demand from users. In other words, deal breaker traits are those traits that the variety possess as a sufficient condition for a buyer to take decision to buy. This study therefore seeks to identify those traits that a cassava variety should possess that will facilitate farmers' preference and willingness to buy the variety.

METHODOLOGY

The study was carried out in south-east and south-south geopolitical zones of Nigeria. Two states were purposively selected from each zone based on BASICS activities in the states. In South-East, Abia and Imo states were selected while in South-South; Cross River and Akwa Ibom states were selected. The respondents were selected from a list of customers who purchased stems from the key CSEs that sold cassava seed during the 2018 planting season. A total of 44 cassava farmers who are customers to the CSEs were identified and selected. The researchers adopted a snowball method to trace the respondents whose distribution is presented in Table 1 below.

Table1: Distribution of respondents according to states

States	Number
Abia	7
AkwaIbom	20
Cross River	5
Imo	12
Total	44

Data collected were analysed using simple descriptive tools such as percentages and a probit regression analysis.

RESULTS AND DISCUSSION

Deal -Breaker Traits of Preferred Improved Cassava Varieties in the study area.

Preference to cassava varieties is pivotal to adoption, utility and commercialization of cassava. Since the varietal traits contained in the seeds cascades down through the product value chain from primary outputs (roots) to secondary products (*gari, fufu*, etc). These traits were characterised into three distinct groups based on farmers' responses as shown in Table 2 below. They include the agronomic traits indicating cassava stems physical features at farm level which forms sources of attraction and a measure of farm level performance of plants amidst diverse climatic conditions. These certified improved cassava varieties show resilience to climate change, soil nutrient and water use efficiency especially during late season farming, they mature early, visibly show good stem architecture which is a good trait for cassava stem entrepreneurs, giving them more value for their labour, good root formation, shape and sizes are some of the best traits identified at farm level as quality agronomic traits.

In addition to this, the second classification of the deal breaker quality traits that leads to increased demand for product is product characteristics at processing level. These varieties show low water content during processing (a proxy for high dry matter), swelling property which is commonly referred to as less-for-better for commercial producers and households with large number of members. For a farmer who is also a processor, an important trait which these improved varieties are renowned for is underground storability. They have proven to have slow deterioration on the field which enables a farmer plan its product marketing regime and possibly take advantage of the off-peak market demand for cassava roots.

Finally, the market-level leading traits as identified from the survey include; brightness of product colour which is a leading property for marketing the product. Products of improved cassava varieties (*Gari, fufu, Abacha*) does not change colour under the sun or extreme conditions or over time. Its swelling property, draw ability of *gari* and *fufu* (a proxy for good starch content) is a market level leading trait of preference that meets consumer demands. Products of certified improved cassava varieties demonstrates visual and textural satisfaction for consumers and the popularization of these qualities leading traits are a yardstick for increased production and sales to attain maximum utility and overall consumer satisfaction. These findings justify previous findings (Bentley et al 2017, Bechoff, et al 2019).

Table 2. Deal -Breaker Traits of Preferred Improved Cassava Varieties in Southern Nigeria

Agronomic traits	Product characteristics	Marketability traits
High yield	Higher dry matter content	Bright colour of products (garri and fufu)
Early maturity	Considerable starch quantity	Swelling property of processed product
Soil nutrient-use-efficiency	Easy to process (Softens quickly) for fufu	Colour (yellow, Off-white)
Resilient to harsh weather and diseases	Yellow root	Very high demand market for product (stem and roots)
Excellent stem architecture	Underground storability of roots post maturity	Good starch quality for fufu (draw ability)
Good root size and formation	Good for garri processing	Products meet consumers visual and textural preference
Newness of product	Nutritional added advantage	Popularity of products in the area

Source: Field Survey, 2020

Willingness to buy certified improved cassava stem in South east and South-South Nigeria

The result of the probit regressions analysis presented in Table 3 reveals a pseudo-R squared value of 0.4148 and chi square value of 31.35 statistically significant at 1% level of probability indicating the goodness of fit of the regression equation. Three (3) out of the eleven (11) independent variables were statistically significant at different probability levels. These include planting of local varieties which had a direct relationship with willingness to buy the certified improved cassava varieties at 5% level of probability. This shows that majority of farmers who are willing to buy improved varieties are those who plant local varieties and are willing to try something new. Furthermore, purchase of variety TME 419 had a positive relationship with willingness to buy, statistically significant at 10% level of probability reflecting an increased demand for the variety. The more they purchase this variety, the higher their willingness to buy more. Those who had purchased TME 419 cassava varieties earlier are more willing to buy, having seen the performance of the cassava variety. This could be because the variety has become popular due to its deal-breaker traits that meets the diverse needs and preferences of different categories of consumers. Conversely, the variable purchase of TMS 01/1368 had an inverse relationship with willingness to pay at 10% level of probability. Which reflects a decline in willingness to purchase the cassava stems. This means that any farmer that purchased the variety will not be willing to pay for it any more, thereby confirming the position of Ayinde (2017) that adoption and consumption of bio-fortified pro vitamin A cassava varieties remain low in Nigeria. Also, in a related study, Onyeneke

(2020) identified some constraints to adoption of bio-fortified cassava to include among others, quick root deterioration and high moisture content. These are poor processing qualities that may discourage purchase of seed of the yellow root variety.

Table. 3. Parameter estimates of the Probit regression on willingness to buy certified improved cassava stems in Southern Nigeria

Variables	Coefficient	Standard. Error	z-value
Constant	2.43	0.99	2.45**
Age	-0.32	0.25	-1.32
Use to buy seeds	-0.22	0.16	-1.36
Distance from farm	0.035	0.023	1.53
Planting of local varieties	1.040	0.49	2.11**
Price of seed (₦/bundle)	-0.00047	0.00053	-0.88
Area certified seeds (hectare)	-0.20	0.16	-1.27
Have income problem	-.073	0.20	-0.36
Purchased TME 419	0.99	0.59	1.67*
Purchased TMS 98/0581	-0.39	0.72	-0.54
Purchased TMS 98/0505	-1.09	0.70	-1.57
Purchased TMS 01/1368	-1.017	0.58	-1.77*
Number of obs	44		
LR chi2(3, 11)	31.35***		
Pseudo R^2	0.4148		
Log likelihood	-22.108291		

Source: Probit result computed from STATA14.0* is significant at 10%, ** significant at 5%

CONCLUSION

Deal breaker traits in a cassava variety plays an important role in determining the preference and willingness to buy such varieties. From the study, cassava varieties that possesses certain agronomic traits (high yielding, early maturing, soil nutrient -use efficiency, resilient to harsh weather and diseases, excellent stem architecture and good root size), product characteristics (high dry matter, considerable starch quality, easy to process (ferments quickly) for fufu, root colour, and nutritional added advantage) and marketable traits (bright colour, good swelling property, high market demand, good starch quality, good visual and textural quality and popularity of product in the area) are considered to possess deal breaker traits that determines the preferences and willingness to buy such varieties. The TME 419 variety is the most preferred variety. The probability of farmers to buy and continue to use TME 419 is significant whereas there is high probability for farmers who have used TMS 01/1368 to stop using it. It is therefore recommended that seed producers should increase the multiplication of TME 419 to meet its increasing demand.

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Determinants of adoption of information and communications technology (ICT)-based market information services by smallholder farmers and traders in Benue State, Nigeria

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ABSTRACT
Market access is increasingly relying on Information and communications technologies (ICTs) like telephony and internet that are only adopted haphazardly. Despite the need for ICTs in Market Information Services (MIS), ICT usage in Africa is low. Little is known about ICTs for use in MIS including, technology, its potential users and characteristics of both entities. The study examined ICT components used and factors influencing the adoption of the components used. Stratified random sampling was used to select respondents and data were collected from them using structured questionnaires. The data collected from 150 farmers and 50 traders were analysed using descriptive and influential statistics with the aid of STATA statistical package. Radio was the most used old ICT, whereas mobile phones were most used new ICT. Expensive handsets, poverty, poor power supply, lack of expertise and poor network coverage limited ICT use. Farmers with knowledge of ICT groups and those thinking that ICTs benefited agriculture were the more likely adopters of ICT-based MIS. Family size and land farmed influenced farmers' adoption, whereas age, trading experience, family size and monthly expenses influenced traders' adoption. Farmers and traders who majorly used ICTs for making profit were more likely to use mobile phone whereas those who stayed further from towns were less likely to use the component.

INTRODUCTION
Access to markets has been one of the major factors that have influenced smallholder agriculture in developing countries. Accessing markets allows smallholder farmers buy inputs and sell surplus of their subsistence and semi subsistence agriculture to enhance household incomes (Barrett, 2008). These markets can be between communities, villages, sub counties or countries. Markets that are often accessed by smallholder farmers who form majority of the poor in developing countries are characterized by poor infrastructure and limited investment capital (Barrett and Swallow, 2006). Market access helps alleviate poverty through commercializing agriculture and result in uniform distribution of incomes in developing countries (DCs).
Income distributions in DCs are biased by corruption tendencies which have hindered improvement in household welfare (Dao, 2008). Progress in household welfare is dependent on increments in productivity of household stocks of land, labour and capital through adoption of better agricultural technologies that foster economic growth and alleviate poverty (Barrett and Moser, 2003). Even though important innovations continuously occur in many developing countries globally, Africa inclusive, new technologies are only adopted at a slow pace and haphazardly (Singh, 2006). The slow pace of new technological adoption has kept household incomes low.
However, increase in incomes would enable poor households save more financial resources and consequently gain required financial ability to invest in new technologies that are needed in commercial agriculture (Okello, 2005). Most developing countries like Nigeria are characterized by poor infrastructure in roads and poor administrative systems that are ethnic based and usually marginalize sections of poor farmers and traders, hence restricting smallholders' access to markets (Nwafor et al 2019).

ICTs are generally defined as a combination of activities that enhance capture, storage, processing, transmission and display of information by electronic means (Rao, 2004). These Information and Communication Technologies (ICTs) include cellular phones, internet/email, World Wide Web, Print media, and digital radio receivers. Sustainable information exchange in agricultural markets, technology and knowledge is becoming a critical area of agricultural development. Information exchange seems to be given limited priority and in agriculture the bulky load of agricultural information exchange between farmers and agricultural experts and advisors has been left to extension agents. The effectiveness and efficiency of these extension agents have been declining partly due to limited funding from support organizations like government and donor agencies, and the high costs required in maintaining and sustaining the physical movements of these agents between the rural areas where farmers are found, and the urban areas where agricultural experts are mostly stationed (Nwafor *et al.*, 2019).

Majority of factors affecting adoption of ICTs for MIS are generic in nature. For instance cost effectiveness and speed of information transfer, organizational characteristics like business size, system characteristics like availability and access to ICT services, and internal and external characteristics of the business household like education, past experience in using ICTs, attitude towards ICTs, business objectives and incomes among others (Windrum and Berranger, 2002; Dholakia and Kshetri, 2004). Galloway and Mochrie (2005) further opined that usage of ICTs by smallholder households that inhabit mainly rural areas is constrained by limited education and poor technological infrastructure.

With the current need of efficiency in understanding market price trends, accessing inputs and support services, farmers and traders need to use more efficient and appropriate new ICTs to take advantage of the existing opportunities. Timely access to market information, inputs and other necessary information services like weather changes, pest control techniques and others would increasingly enable small-scale farmers and traders make timely, reliable, realistic and economically viable decisions concerning what crops to grow, when to grow them, what products are for sale when and where, what inputs to use and how to use them. The main objective of this study was to assess the adoption of ICT-based market information services (MIS) by smallholder farmers and traders

MATERIALS AND METHODS

This study was conducted in Benue State, Nigeria. The state has a population of about 5,741,800 National Bureau of Statistics (NBS) (2016); its total land area is 34,059km^2 and it is the 11th largest land mass in the country. Benue State falls within longitude $7^{0}47^{1}$, 10^{0}0E and latitude $6^{0}25^{1}$, $8^{0}8^{1}$N, the state shares boundaries with five other states in Nigeria. Benue State is divided into three senatorial districts, namely, North East senatorial district (Zone A) North West Senatorial District (Zone B) and Benue South Senatorial district Zone (C). Stratified random sampling was used to select the respondents used for the study and data were collected from them using structured questionnaires. The data collected from 150 farmers and 50 traders across the three senatorial zones were analysed with descriptive and inferential statistics with the aid of STATA statistical package.

RESULTS AND DISCUSSION

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Table 1 presents a focus on some characteristics of the sample considering two broad sample strata; adopters and non-adopters. Means of education, experience in using ICTs, monthly income and distance to nearest town were statistically significantly different between adopters and non-adopters of ICT-based MIS. The class of households' monthly income, costs and distance covered to and from the nearest town were statistically different across groups

Table 1. Socio-economic characteristics of respondents (farmers and traders)

Mean values of farmers and traders						
		Farmers		Traders		
Variable	**Over all means (N=200)**	**Adopters (N=84)**	**Non adopters (N=66)**	**Adopters (N=40)**	**Non adopters (N=10)**	**F-test**
Experience	3.16 (3.81)	3.67 (4.35)	1.70 (3.15)	4.15 (3.17)	4.5 (2.7)	5.387***
Age	37.6 (11.4)	37.82 (12.12)	37.44 (11.87)	36.67 (9.47)	40.8 (7.9)	0.364
Education	6.52 (5.45)	6.68 (5.52)	5.71 (5.33)	8.08 (5.19)	4.3 (5.8)	2.184*
Income	75,322 (66,504)	72,428 (75,435)	62,705 (57,186)	103,916 (57,800)	68,516 (47,836)	3.467**
Family size	4.79 (3.34)	5.02 (3.32)	3.98 (2.74)	5.30 (4.05)	6.1 (3.3)	2.280*
Monthly costs	5,008 (6,019)	4,867 (6,772)	4,284.1 (6,780)	6,437.5 (2,678)	5,250 (1,296)	1.093
Distance	2.36 (1.05)	2.49 (1.00)	2.70 (0.96)	1.719 (1.04)	1.55 (0.59)	11.131***

*, **, ***Represents significance at 10, 5 and 1% levels, respectively,
Source: Survey data, 2020
The figures in parentheses are standard deviations

Logit model estimates of the determinants of traders' adoption of ICT-based MIS.

Logit model are presented in Table 7 and show that knowledge of existence of ICT groups perceived benefit of ICTs to agriculture and family size and land farmed in previous season significantly influenced adoption of ICTs for MIS by farmers. A one person increase in family size increased the probability of farmers to adopt ICTs for MIS by 60%.

Contrary to *a priori* expectations, an acre increase in land farmed previous season reduced probability to adopt ICTs for MIS for farmers by 15.3%. Farmers who had positive perception towards ICTs and those who had knowledge of existence of ICTs were more likely adopters than their counterparts. Though had a low participation in ICT usage (Table 1), women were more likely to likely to adopt ICTs for MIS than males. Table 8 presents Logit model results of factors influencing Traders' adoption of ICT-based MIS. Age of the trader, trading experience and monthly costs, family size, asset base, later age and better education significantly influenced the probability of adopting ICTs for MIS by traders. A one person increase in the family size of traders' household increased the probability of adopting ICTs for MIS by 0.09%, as a one year increase in age and trading experience reduced such adoption by 0.08 and 0.03%, respectively. At later age, adoption of ICTs reduced more rapidly. A one shilling increase in monthly costs increased probability of ICT adoption by 0.18%.

Much of small-scale household farming in the study area was mostly practiced by women who had the primary responsibility of farming for household food security as mothers. Therefore males were less likely to devote to the use of ICTs in agricultural market information exchange. Having knowledge of ICT groups' existence availed farmers with an opportunity that attracted them to use and adopt ICTs for MIS. ICT groups were the sources of information and learning on how to use ICTs and benefits of ICTs, thus the positive influence is consistent with (Pickernell et al., 2004). ICTs enabled farmers to access general agricultural information like weather patterns, pests control, mobile money and others that were required in crucial decision making. That was consistent with Opata et al. (2011) and Peansupap and Walker (2005) who found positive perception towards ICTs being positively associated with expansion in ICT use.

Households mainly farmed for household food supply and mainly used rudimentary tools like hand hoes, knives and family labour. The average family size of farmers was small; below six persons (Table 3). Household average incomes were also very small and majority earned below 30 US $ per month (Table 3). Findings were consistent with Njuki et al. (2008) who found that large output proxied by large farm size in this research markets itself hence limiting need for market searches that were largely done using ICTs. However, Warren (2003) found that there was a positive association between farm size and ICT use. Increase in monthly costs on ICTs implied increased use and realisation of economic purpose of ICTs to traders hence traders' attraction to ICT-based MIS as costs increased. Whenever monthly costs increased, traders shifted to more efficient ICTs like mobile phones that gave them quick and more reliable information per unit cost, thus an increase in costs positively influenced adoption of ICTs. Nevertheless findings were contrary to *a priori* expectations and conclusions of Kovacic and Vukmirovic (2008) who found monthly costs to be negatively associated with the likelihood to use and adopt ICTs.

With more age and trading experience, traders mastered business patterns, the trends and tactics of the business environment, thus reduction in need and use of ICTs for MIS. +-Varying locations of family members necessitated more the need of communicating with each other using a more mobile device, thus increasing likelihood of using a mobile phone as compared to pay phone. Knowledge of ICT groups attracted households to gain membership to these groups in which they were more likely to be advised on using modern ICTs like mobile phones, thus a decreasing likelihood to use pay phone as compared to mobile phone. Having ICT groups' knowledge constituted a human capital and consequently a social asset as defined by (Parkinson and Ramirez, 2006). Increased experience in using ICTs enabled households acquire better skills and interest to use more complex ICTs like WWW and internet/email, consistent with Bailey (2009) who established that experience in using ICTs was positively associated with use of modern ICTs particularly the internet. With increasing incomes, households were less likely to use www, CD-ROM and internet/e-mail compared to mobile phone because these components were more capital intensive than mobile phones. Using internet or www required buying a computer and internet services.

Logit model estimates of the determinants of traders' adoption of ICT-based MIS.

Variable	Coefficient	Marginal effects
Family size	6.793 (3.105)**	0.00091
Age	-5.778 (2.499)**	-0.0008
Trading experience	-1.875 (0.809)**	-0.0003
Asset base	-3.803 (1.872)**	-0.0005
Age$_s$	0.063 (0.027)**	0.00008
Education	0.102 (0.044)**	0.00001
Monthly cost	13.076 (5.558)**	0.00175
Constant	55.687 (39.126)	

**, significance at 10 and 5% levels,

Figures in parentheses are standard errors

Logit model estimates of determinants of farmers' adoption of ICT-based MIS.

Variable	Coefficient	Marginal effects
Gender	-2.058 (1.185)*	-0.409
Knowledge of ICT groups	2.318 (0.967)**	0.522
Thought if ICTs benefit agriculture	5.941 (1.395)***	0.872
Education of respondent	1.387 (1.115)	0.340
Monthly cost on ICTs	-0.268 (0.388)	-0.066
Family size[a]	2.453 (0.715)***	0.602
Distance to nearest town center[a]	0.691 (0.748)	0.169
Land farmed previous season	-0.626 (0.278)**	-0.153
Constant	-7.213 (4.264)*	

; *, **, ***, significance at 10, 5 and 1% levels,
Figures in parentheses are standard errors

CONCLUSIONS

Mobile phone was one of the most important ICT components used by households to access market information services. Family size significantly and positively influenced ICT-based MIS adoption for both small-scale farmers and traders and having knowledge of ICT groups' existence availed farmers with an opportunity that attracted them to use and adopt ICTs for MIS. Therefore, innovation on ICTs should be stended to farmers via ICT groups and farmers organization

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Patronage of Supermarkets by Women in Ibadan Metropolis

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ABSTRACT

This study sets out to examine the frequency, reasons for patronizing supermarkets and factors that determines the patronage among women in Ibadan metropolis. A total of 300 respondents were selected using multi-stage random sampling techniques. The result of the analysis shows that about 30.7% of the respondents had never shopped in a supermarket while 39.4% patronizes supermarket once in a month. The major reason for patronizing supermarket in order of importance is convenience. Factors that determine patronage of supermarkets are income, distance to the nearest supermarket, perceived quality of the products and ease of shopping. The study therefore concludes that there is growing importance in roles that supermarkets play in the economy of the nation. Therefore, factors that encourage its patronage should be advocated by all relevant stakeholders. Supermarkets owners should also ensure that they continue to sell products that are of high quality as it is one of the major factors that determine its patronage.
Keywords: Determinants, Patronage, Supermarket and Women
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INTRODUCTION

The retail food outlets including supermarkets, hawkers, and open-air markets connect consumers to their food choices and there is an increase in competition among types of modern stores: grocery stores, supermarkets, discount stores, department stores, catalog showrooms Retailing is an essential service industry as it provides an important service to customers, making products available when and where customers want them. Extant literature shows that retailing can take many forms, both store and non-store forms Oghojafor et al 2012. Whatever the form, the customer is called upon to make a choice. Thus, consumer decision-making involves not only the choice of product and brand but also the choice of retail outlet (Jobber, 2009). Retail choice and patronage are hardly a single factor phenomenon (Verhallen & de Nooij, 1982; and North & kotze, 2004).

Supermarkets play a crucial role in introducing new processed foods or nutritious products, such as exotic out-of-season fruits or conveniently packaged vegetable snacks (Hawkes 2008) and there has been an increase in competition among types of modern stores: grocery stores, supermarkets, discount stores, department stores, catalog showrooms; they are competing for the same customers. (Kotler and Keller 2006). However, there are also some critics of different food outlets (i.e., supermarket, open-air market, and hawkers). For instance, supermarket expansion may be related to modern health problems such as obesity (Michimi and Wimberly 2010). Also, it has been shown that low food quality is often closely related to food products offered by hawkers (Hanashiro *et al.* 2005; Rane 2011). Similarly, practicing appropriate sanitation guidelines and periodic bacteriological control is necessary in open-air markets to reduce food contamination (Filiousis *et al.* 2009). Also, retail shopping behavior has been predicted by means of objective variables like distance, traffic patterns, population density and store size (Alpert, 1971).

Growing incomes, expanding retail outlets, and changing consumer preferences in developing countries especially Nigeria calls for an examination of the choice of retail outlets by consumers, frequency of visits to modern retail outlets, reasons for patronizing supermarkets and factors that determine patronage of supermarkets are examined in order to generate policies for stakeholders in the industry that will bring about the desired growth for the industry through advocating for its patronage by promoting factors that drives its patronage .

METHODOLOGY

The study was conducted in Ibadan metropolis area of Oyo state. Ibadan is the capital city of Oyo State and the third largest metropolitan area, by population, in Nigeria, with a population of over 3 million. Ibadan is also the largest metropolitan geographical area. At Nigerian independence, Ibadan was the largest and most populous city in the country and the third in Africa. Ibadan is located in south-western Nigeria, 128 km inland northeast of Lagos and 530 km southwest of Abuja, the federal capital, and is a prominent transit point between the coastal region and the areas to the north. The city ranges in elevation from 150 m in the valley area, to 275 m above sea level on the major north-south ridge which crosses the central part of the city. The Heritage Mall and Coco mall in Ibadan houses several local and international retail stores The 2 malls contain International South African retail shop SHOPRITE, Pep store, dines and wines, restaurants, electronic outlets, Mr price, Cash n Carry, LG electronics, e.t.c. The metropolis also has other supermarkets such as Foodco, Feedwell, Extra miles.

A multi-stage sampling technique was employed in the selection of the respondents. The first stage was the random selection of three Local Government out of the five Local Governments that are classified as urban centers. Stage two was the random selection of five enumeration areas as stratified by the government during the 2006 population census. Stage three was the random selection of 20 housing units from each of the enumeration area to give a total of 300 respondents. A total number of 244 questionnaires were retrieved which served as the sample size.

Frequency of visits to supermarkets and their reasons for patronizing supermarkets were analyzed through the use of descriptive statistics and Probit regression analysis were implored to identify the factors that determines the probability that household will patronize supermarkets.

The model is specified as

$$Y(\beta X_i) = \int_{-\infty}^{\beta \chi i} 1 \Big/ \sqrt{2t} \;\; \exp\left(-t^2 \Big/ t\right)^2 dt$$

Where Y is the dependent variable, which is if the respondents patronize or do not patronize supermarkets.

0 =Patronize

1 = Do not patronize

t is the random variable, which is distributed as a standard normal deviate. β is a vector of unknown coefficients. X_i is the vector of characteristics of the i^{th} individual and are the independent variables, which are defined as follows.

X_1= Age (in years)

X_2=Income (₦)

X_3=Spouse Income (₦)

X_4=Household size (In numbers)

X_5=Distance to nearest supermarket (In Km)

X_6=Years of formal education (in Years)

X_7=Perceived quality of products (1 = products bought are genuine when compared with open market 0 = otherwise)

X_8=Perceived prices of products (1 = prices of supermarket are comparable or cheaper than other retail outlet 0 = otherwise)

X_9=Ease of shopping (1=shopping at supermarket is convenient when compared with other outlet 0= otherwise)

Constant term

RESULT AND DISCUSSION

Patronage of Supermarkets

Figure one shows the respondents patronage or not of supermarkets. The result shows that while 30.7% of the respondents do not patronize supermarkets and shopping malls 69.3% of the respondents purchase goods from supermarkets. This implies that there are some respondents who still adhere to the traditional open market system/hawkers for the purchase of their goods.

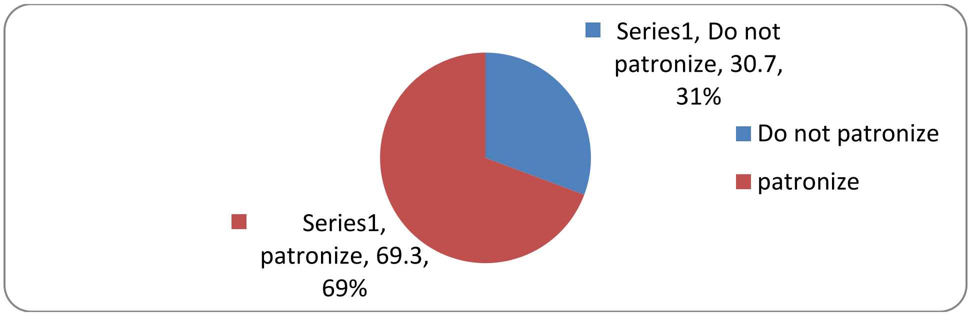

Figure one: Patronage of Supermarkets

Frequency of Patronizing Supermarkets

Figure one presents the result of the frequency of patronizing supermarkets. It was observed from the result that 30.7% of the respondents have never visited a supermarket for shopping. The result further indicates that majority of the respondents (40.2%) patronizes supermarkets only once in a month. This is expected as majority of the respondents are salary earners and they get paid only once in a month. Furthermore, most women receive housekeeping allowance once a month. They therefore tend to shop on a monthly basis when they receive their remunerations.

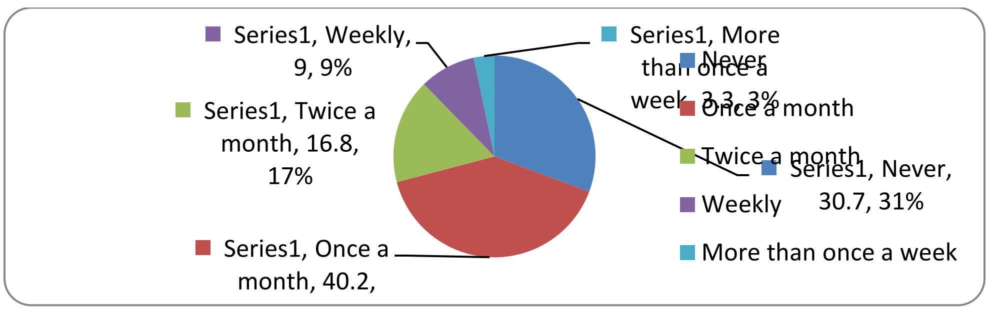

Figure two: Frequency of Patronizing Supermarkets

Reasons for Patronizing Supermarkets as Retail Outlets

The major reason for patronizing supermarket in order of importance is presented in table 1. The result shows that majority of the respondents (36.1%) identified convenience as their major reason for patronizing supermarket. This is followed by the quality of the products sold in the supermarkets that was ranked second by 32% of the respondent.

Table 1: Reasons for Patronizing Supermarkets

Reasons for Patronizing Supermarkets	Rank					
	1st	2nd	3rd	4th	5th	6th
Price mechanism	28 (16.6)	16 (9.5)	15 (8.9)	45 (26.6)	49 (29.0)	16 (9.5)
Quality of the Product	24 (14.2)	54 (32.0)	21 (12.4)	32 (18.9)	11 (6.5)	27 (16.0)
Convenience	61 (36.1)	22 (13.0)	09 (5.3)	08 (4.7)	30 (17.8)	39 (23.1)
Cleanliness	14 (8.3)	30 (17.8)	53 (31.4)	11 (6.5)	12 (7.1)	49 (29.0)
Parking Space	32 (18.9)	27 (16.0)	30 (17.8)	50 (29.6)	29 (17.2)	01 (0.5)
Location	10 (5.9)	20 (11.7)	41 (24.2)	23 (13.6)	38 (22.4)	37 (21.9)

Source: Field survey 2021

***Figures in parenthesis are in percentages**

Reasons for not patronizing supermarkets

Table two presents the reasons why respondents doss not visit supermarkets. The outcome of the analysis indicates that the major reason why most of the respondents (40%) do not shop at supermarkets are due to the fact that they do not have provisions for credit facilities. This is followed by the fact that they engage in bulk purchasing (37.3%) and due to the large quantities, that they require they prefer to do their shopping at open-markets.

Table 2: Reasons for not Patronizing Supermarkets

Reasons for Not Patronizing Supermarkets	Rank			
	1st	2nd	3rd	4th
Bulk purchasing	15 (20)	28 (37.3)	17 (22.7)	15 (20.0)
Unavailability of credit facilities	30 (40)	20 (26.7)	16 (21.3)	9 (12.0)
Location	23 (30.7)	10 (13.3)	24 (32.0)	18 (24.0)
Low literacy level	7 (9.3)	17 (22.7)	18 (24.0)	33 (44.0)

Source: Field Survey 2021

***Figures in parenthesis are in percentages**

Determinants of patronizing Supermarkets by Women

Factors that determine patronage of supermarkets are income, distance to the nearest supermarket, perceived quality of the products and ease of shopping. Income was a positive significant factor that women will likely patronize supermarket at $p<0.05$. Distance to the supermarket also had a positive effect on the likelihood that women will patronize supermarket which was also significant at $p<0.01$. Perceived quality of the products also had a positive and significant effect on the likelihood that households will patronize supermarket at $p<0.01$. Ease of shopping was significant at $p<0.05$ level and positively related to the probability that urban women will patronize supermarket.

Table 3: Determinants of Patronage of Supermarket

Variables	Parameter Estimate	Marginal Effect	Standard Error	Parameter
Age	-0.03	-0.00	0.35	0.93
Income	2.17	0.11	1.11	0.04
Spouse Income	1.47	0.06	1.25	0.24
Household size	0.07	0.00	0.18	0.69
Distance to nearest	1.13	0.05	0.34	0.00
supermarket	0.45	0.02	0.22	0.06
Years of formal education	4.75	0.54	1.52	0.00
Perceived quality	0.12	0.00	0.16	0.46
Perceived price	8.79	1.97	4.19	0.04
Ease of shopping	0.35		0.12	0.03
Constant term				

CONCLUSION AND RECOMMENDATION

This study examined the patronage of supermarkets, frequency of visits, reasons for patronizing and not patronizing of supermarkets among women in Ibadan metropolis of Oyo State. The study shows that while some women patronize supermarkets some still adhere strictly to the traditional open market system. The result of the analysis identifies convenience, quality of the products sold at supermarkets and cleanliness of the environment of the supermarkets as the major reasons while they patronize supermarkets. Factors that determine patronage of supermarket are income, distance to the nearest supermarket, perceived quality of the products and ease of shopping.

Supermarket owners should therefore endeavor that they continue to ensure that attributes such as convenient shopping procedures, high quality products and cleanliness of environment that endears customers to patronize them is maintained. In addition, supermarket owners should look inwardly on how to have facilities for credit purchase so as to enhance their level of patronage.

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Effect of Youth in commercial Agriculture Development programme, in Ekiti state. Nigeria

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ABSTRACT
The reliance on agriculture for food production and food security at domestic, regional and global levels depend on youth productive force. While their contribution towards attaining food security cannot be underestimated, yet their apparent lukewarm effect towards agriculture is a source of concern. This study assessed youth participation in Commercial Agricultural Development Programme in Ekiti state.

Interview schedule were conducted on one hundred and eighty-four (184) of both active and non-active youth participants using structured questionnaire. Data analyses were through the use of frequency, percentages, means and t-test were used to test the hypothesis of the study. The findings revealed that the majority of youth sampled were male (92% and 88.1%), majority between the ages of 31-35 years (56%) with mean age of 35 years. Most of them were married (93.3% and79.8%) Also, majority of them were illiterate (86.7% and79.85%) and had been farming for a period of 6-10 years of active participant also, non-active (50.5%) had farming experience of less than 5years. Majority of active participants (76%) were full time farmers while (68%) of non-active were part-time farmers. The result revealed that youth have positive attitude towards the YCAD programme. Also 89% of active and non-active 79% of variations in the dependent variable (output level) was explained by the independent variable (socio-economic characteristics). It is concluded that the youth commercial agricultural programme have positive effects on youth participation in the programme.

Keywords; Effect of Youth in commercial Agriculture Development programme, Youth participation, Agricultural production,

INTRODUCTION
The role of Agriculture remains significant in Nigeria economy despite the strategic importance of the oil sector. Agriculture primarily provides employment for Nigerians and accounts for more than one third of total gross domestic product (GDP). More than 70% of the working populations in Nigeria are employed in the agricultural sector directly or indirectly and over 90% of Nigeria's agricultural outputs come from peasant farmers who live in rural areas (Abubakar, 2016). The reliance on agriculture for food production and food security at domestic, regional and global levels depend on youth productive force. This is the generation which is expected to rise in the coming years for food production and food security (Proctor and Lucchese, 2017). Agriculture in Africa has untapped potential to create jobs both directly and indirectly in order to attract young people, agriculture will need to be more dynamic and appealing than it is now and young people will need to view the sector more positively than they do now (Institute of development studies, 2012) and Fayemi, 2012 noted that without effective policies and agenda on youth development, the benefits

of economic growth will continue to by-pass a significant proportion of Nigerians, including our teeming population of youths.

Globally, youth is described as the period in an individual's life, which runs between the end of childhood and entry into the world of work (Onuekwusi and Effiong 2007). Youth is seen as universal stage of development, according to Nigeria's National Youth Development Policy, the youth comprises all young persons of age 18-35 who are citizens of the Federal Republic of Nigeria. A major concern of the Nigerian Government is how to tackle the problem of unemployment among the youths in the country. Various regions in Nigeria have designed and executed several self-empowerment programmes to enhance the economic empowerment of youths (Umeh and Odo 2002). One of such programmes is Youth Commercial Agricultural Development Programme (YCAD) which was initiated in 2012 to accelerate the process of Agriculture commercialization in Ekiti State and help to increase employment opportunities for youths, value addition of specific agriculture products and increased Internally-Generated Revenue (IGR). It is crafted to systematically mobilize the youths into sustainable commercial agriculture, generate employment opportunities to potential young entrepreneur by promoting High Value Crop (HVC) production, processing and marketing under a holistic value development agenda. The programme focuses on youth who are graduates, Diploma and school certificate holders. It focuses on Arable crops, Nursery, Processing, Livestock and Aquaculture.

MATERIALS AND METHOD

Sampling Procedure and Sample size

The study was conducted in Ekiti state, population count was 239 registered participants of the YCAD programme. The list was further segregated into two; active participants and inactive participants. And samples were randomly selected

A simple random technique was used to select of 70 % of 83 active participants.

In addition, 70% of the 156 non-active Participants were also randomly selected to give a total sample size of 184 respondents. And data were collected using a structured questionnaire.

Measurement of Variable Dependent Variables

The dependent variable for this study was youth participation in commercial agriculture

Independent variables: The independent variables used for this study was; Age, gender, marital status, Level of education, level of youth participation,

Dependent variables include:

To examine the effect of the socio economic factors on youth participation in YCAD programme, thirteen-item statements was presented and assessment based on a 5 – point Likert scale of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) Strongly Disagree (SA) and scores of 5, 4,3,2,1 was assigned to the corresponding responses for positive statement and the reversed scores for the negative statements.

Assess the youth perception of the extent to which the objectives of the programme met was measured using a 4- point likert-type scale of Highly satisfied=1, satisfied =2, Dissatisfied =3, highly Dissatisfied =4. This was asked from the respondent maybe the programme has influenced them positively or negatively.

Data Analysis

The statistical tools that were used for data analysis for this study include both descriptive and inferential statistics. Descriptive statistics involving frequency counts, percentage, and mean and ranking were used to analyze objectives 1, 2, 3 and 4 While Regression Analysis and t-test were used to test the hypotheses of the study.

RESULTS AND DISCUSSION

Socio – Economic Characteristics of Youth

Table 1 Distribution of Respondents according to their socio-economic characteristics

Variables	A n=75		N.A n=109	
	%	Mean	%	Mean
Age: 31-35 35-40	 37.3	 35	30.3	36
Gender: M F	92 8		81.1 11.9	
Education: Sec Tert	13.3 86.7		20.2 79.8	
M.S: Single Married	6.6 93.3		20.2 76.8	

H. size: 1-5 **6-10**	**93.3** **6.3**	**4**	**90.8** **9.2**	**4**
Farm Exp: 6-10	**33.3**	**10**	**33.9**	**7**
N.P:Full time **Part-time**	**76** **24**		**31.2** **68.8**	

Source: Field Survey 2021

Key: A=Active, N.A=non-active, M=male, F=female, Sec=secondary, Tert=tertiary, H.size=Householdsize, NP=Nature of participation, M.S= marital status.

Table 1 revealed the socio economic characteristics of active participants about'56% of the respondents were within the age of 31 – 35 years, with 86.7% while the non-active participants about 51.4% of respondents were within the age of 36-40 years, the active participants are in line with the study conformed to the United Nation (2019) definition of youths as people within the mean age of 35 years.

Majority of the respondents both active and non-active attained basic level of education while (86.7%) and (79.8%) attained tertiary education. This finding is confirmed by Muhammad-Lawal et al (2009) whose study showed that a greater percentage of the participants (93.64%) in youth agriculture programme in Nigeria had some form of formal education.

93.3% of the active participant were married while 79.8% of non-active participant was married, also revealed that a high proportion of the active respondents (93.3 %) have a household size of 1-5 while the non-active respondent (90.8%) of the same household size.

The field results also showed that about (33.3%) of active participant have had farming experience of 6-10 years and non-active (50.5%) had farming experience of less than 5 years in farming.

Majority of the youths interviewed (76%) of active participant were full-time farmers, while majority (68.4%) of non-active were part-time farmers. These show maybe non active participants have something doing somewhere that is more profitable than agriculture.

Assess Youth Perception of the Extent to which the Objective of the Program has been met

Table 2. Youth Perception towards the Objective of the YCAD Program

YCAD OBJECTIVE	**HS (1)**		**S (2)**		**D (3)**		**HD (4)**		**Mean**		**Rank**	
	A	NA	A	NA	A	NA	A	NA	A	NA	A	NA
Incentive	8 10.6%	0 0.0%	31 41.3%	7 6.4%	31 41.3%	45 41.3%	5 6.6%	57 52.3%	2.44	2.78	9th	1st
Credit facilities and subsidies	6 8%	3 2.8%	29 38.6%	28 25.7%	36 48%	73 66.9%	4 5.3%	5 4.6%	2.50	2.73	8th	10th
Modern agric. Equip.	9 12%	7 6.4%	38 50.6%	42 38.5%	28 37.3%	58 53.2%	0 0.0%	2 1.8%	2.25	2.50	17th	16th
Basic social amenities	2 2.6%	0 0.0%	17 22.6%	14 12.8%	38 50.6%	65 59.6%	18 24%	30 27.5%	2.96	3.14	4th	6th
Land tenure sys.	2 2.6%	1 0.9%	48 34%	61 55.9%	22 9.3%	43 39.4%	3 4%	4 3.7%	2.34	2.45	14th	17th
Long invest period in agriculture	4 5.3%	3 2.8%	42 56%	36 33%	22 9.3%	56 51.4%	7 9.3%	14 12.8%	2.43	2.74	11th	9th
Marketing of agric products	3 4%	3 2.8%	10 13.3%	16 14.7%	36 48%	50 45.9%	26 34.6%	40 36.7%	3.13	3.16	2nd	3rd
Training	13 17.3%	11 10.1%	40 55.3%	48 44%	9 12%	25 22.9%	13 17.3%	25 22.9%	2.29	2.58	16th	15th
Transportation	3 4%	1 0.9%	11 14.6%	15 13.8%	33 44%	47 43.1%	28 37.5%	46 42.2%	3.14	3.14	1st	4th
Storage facilities	3 4%	1 0.9%	14 18.6%	23 21.1%	30 40%	37 33.9%	28 37.5%	48 44%	3.10	3.22	3rd	2nd
Tech support from agric ext agencies	6 8%	2 1.8%	36 48%	41 37.6%	28 37.3%	53 48.6%	5 6.6%	13 11.9%	2.42	2.70	10th	11th

Access to financing service in loan and lease	3 4%	2 1.8%	28 37.3%	29 26.6%	35 46.6%	66 60.6%	9 12%	12 11%	2.66	2.80	6th	7th
Structured disbursement/repaymt of loan	1 1.3%	0 0.0%	22 29.3%	24 22%	44 58.6%	75 68.8%	8 10.6%	10 9.2%	2.80	2.78	5th	8th
Training of farmers on modern & tech input by service providers	7 9.3%	5 4.6%	36 48%	32 29.4%	31 41.3%	65 59.6%	1 1.3%	7 6.4%	2.34	2.67	15th	13th
Labour availability	5 6.6%	3 2.8%	17 22.6%	18 16.5%	51 68%	68 62.4%	2 2.6%	20 18.3%	2.66	2.96	7th	5th
Technical skills	8 10.6%	6 5.5%	46 61.3%	56 51.4%	19 25.3%	42 38.5%	2 2.6%	5 4.6%	2.20	2.42	18th	18th
Supply of inputs	7 9.3%	5 4.6%	34 45.3%	33 30.3%	30 40%	62 56.9%	4 5.3%	9 8.3%	2.41	2.68	12th	12th
Supply of commercial farm management skills and capacity building services by international development institutions	6 8%	4 3.7%	38 50.6%	34 31.2%	29 38.6%	66 60.6%	2 2.6%	5 4.6%	2.36	2.66	13th	14th

Source: Field Survey 2021

KEY: A= Active, NA=Non-Active, 1=highly satisfied. 2=satisfied, 3=Dissatisfied, 4=Highly Dissatisfied

Table 2 shows the effects of YCAD on youth's participation in agriculture. A great number of active participants agreed that the programme should continue because it has reduced their poverty level while most of non-active disagreed with this perception with the mean ratio of 4.25 and 3.77. Majority of the active participants agreed that the programme has been the source of employment while non active participant strongly disagreed with this with the mean ratio of 4.38 and 3.56. This implies that Agriculture primarily provides employment for Nigerians and accounts for more than one third of total gross domestic product (GDP). More than 70% of the working populations in Nigeria are employed in the agricultural sector directly or indirectly. (Abubakar, 2016).

Table 2. **s**hows that perception of youth towards the objectives of the programme. Majority of the youth are highly dissatisfied with the Marketing of agricultural products for both active and non-active participants as this occupied the second and third position on the ranking with Mean ratio of 3.13 and 3.16, also a great number of respondents dissatisfied with this perception of not giving incentives from government as this occupied the first and ninth position on the ranking with Mean ratio of 2.44 and 2.78.Majority of youth were dissatisfied with the storage facilities for both active and non-active participants as this occupied the third and second position on the ranking with Mean ratio of 3.10 and 3.22. This implies that Lack of infrastructure and essential input also hinders youth to participate in agricultural and rural development activities. (Onuekwusi and Ottah (2006)

Hypothesis Testing

The mean effects scores of active and non-active participants were compared by the use of t-test (Table 3).

TABLE 6: Summary of t-test Analysis Mean active participants	**Mean non active participants**	**t-cal**	**Sig.**
3.071	2.103	0.05	P = 0.05

Source: field survey, 2021

Hypothesis 1: The result showed that there was no significant difference in compared the mean effects scores of active and non-active to YCAD programme. The youth in the study area have positive effects to agricultural development intervention programmes**.**

CONCLUSION

Based on the findings of this study, it can be concluded that level of participations among active participants is high because they spent more time and days in farming activities of their chosen enterprise while non active participants spent less time and days in farming activities

Furthermore, both active and non-active participants were faced with the challenges of storage facilities, transportation, marketing of agricultural products and incentives. Majority of the participants were still in their active age and they have school education which would assist them to communicate and make them to participate more actively in the programme.

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Nexus between Forest and Environment and their Influence on Food Security in Nigeria

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ABSTRACT

Forest constitutes important component of the environment. It covers about one third of the world's land area and provides vital environmental services. It plays valuable roles on food security and sustainable livelihood. This paper therefore looked into the relationship between forest and environment and their influence on food security. The environmental protection role of trees and their direct contribution to food security are examined. It is concluded that forest immensely contributes to the sustainable livelihood of rural and urban dwellers and enhances environmental sustainability.

Keywords: Environment, Food security, Sustainable livelihood, Trees

INTRODUCTION

The word forest

Forest is a renewable natural resource characterized bycomplex ecosystem and consists mainly of trees that cover the earth and support a myriad of life forms (Adeyoju, 2005)**.** The trees help create a special environment which, in turn, affects the kinds of animals and plants that can exist in the forest. Trees are important component of the environment. Forests cover roughly one third of the world's land area and provide vital environmental services such as climate regulation, soil protection and water management (FAO, 2007). They also produce food and raw materials, which sustain hundreds of millions of people and support economies. By and large, a plant community is categorized as a forest when is occupying an area of land more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds at that particular time in that area (FAO. 2007). Invariably, it does not include land that is

predominantly under agricultural or urban land use (FAO, 2001). There are three main different types of forests in the world: tropical forests, temperate forests and boreal forests.
Man lived inside the forest in the very distant past, and was hundred percent dependent on it for shelter, clothing, food, medicine and aesthetic functions (Famuyide, 2005). The practice and art of managing forestlands and other natural resources associated with them such as trees, other plants, wildlife, soil, water, air and the climate, for human benefit, is referred to as forestry which is the major component of the environment (Faleyimu and Arowosoge, 2011)

The environment

The surroundings or the circumstances, in which human beings, other animals and plants live or grow, constitute our environment. It is from the environment that all resources essential for our survival and development are to be found (World Bank, 2011). These resources include non-living parts such as soil and air, and the living organisms. The non-living and living organisms influence and support each other in such a way that they form a community. When the area is large and similar organisms interact with the non-living parts, they work together as an ecosystem (Arongol and Dachomo, 2007). The variety of living things and the non-living parts that sustain them is called biodiversity or the diversity of life. The Nigerian environment is warm and rainfall is important in determining organisms that are found in any location. Nigeria is said to have several ecological zones ranging from lush forest vegetation in the south, Guinea savanna in the middle belt, Sudan savanna in the north and Sahelian vegetation in the far north. Overall, Nigeria is rich in the variety of living organisms (biodiversity) and the systems that support them for sustainable livelihood. (Mailumo *et al*, 2011; Aiyeloja and Faleyimu, 2011).

The word food security

Food Security can be defined as access to adequate and quality food at the individual, household, national and international levels at every given time. The Food and Agricultural Organization (1997), states that Food Security exists when all people, at all times and all levels have access to sufficient, safe and nutritious food to meet their dietary needs for an active and healthy life. Food security, according to the United States Department of Agriculture (USDA), connotes a steady supply of safe and nutritious food for human consumption. An assured ability to acquire acceptable food in socially acceptable ways (that is, without resorting to emergency food supplies, scavenging, stealing or other coping methods or strategies).Food security is associated with food intake at the individual level and its availability at household, sub- national and national levels (World Bank, 1996). A food secured household can be defined as a home which has adequate food for the required intake of its members. Availability of food at the household level depends on many variables. These include, net food production, land, labour, capital, knowledge and technology, food prices and food supply in the market, cash flow, farm rents, and per capita income of consumers (Mailumo *et al*, 2011; FAO, 1997).

The link among forest, environment and Food security

Forest and environment are inseparable. The environment could be conspicuously not in existence without trees and other resources that make up the forest (Aiyeloja and Faleyimu, 2011; Akachukwu, 1997). In the ecosystem environment, forests provide a large proportion of rural households' food needs. The provisions are in two forms: (i) the environmental protection role of trees and forests that enhance water and soil conservation to maintain high levels of productivity; (ii) the direct food commodity contributions which can supplement normal farm yields or serve as substitute products in the event of crop failures due to floods, droughts or insect infestation (Akande *et al*., 2007; Hoskins 1990). Also of major importance are the socioeconomic contributions of forestry to food security.

The environmental protection role of trees

The interception and reduction of air pollution for health and Social well-being
One of the most key values for human health that trees can provide is the interception and reduction of air pollution (McPherson*et al*., 2016; McDonald *et al*., 2016). Air pollution (such as particulate matter (PM), ozone, carbon monoxide, polycyclic aro-matic hydrocarbons, nitrogen dioxide, sulfur dioxide, and so on) is linked to bronchitic symptoms that leads to several ailments in both old and young.(Nwanaji-Enwerem*et al*., 2019; Di *et al*., 2017). Trees remove a tremendous amount of these air pollutants (Nowak *et al*., 2006).
Educational values
Forest serves as a laboratory for several environmental students. It increases literacy and numeracy among the students having had access to the nature. The botanical rambling, forest enumeration and other studies in the forest add to educational values of the students. (Kuo*et al*., 2018).
Economic and Resource value
Trees provide many ecosystem services that can benefit a city environment, ranging from erosion control, soil nutrients conservation, reducing energy use and removing pollution to increasing property values, developing the local economy, and supporting tourism (Nowak and Greenfield, 2018). It has been estimated that trees provide $18.3 billion in annually in United States of America due to air pollution removal, reduced building energy use, carbon sequestration, and avoided pollutant emissions just in an enclosed forest of a country (Nowak and Greenfield, 2018).
Climate change Amelioration
Climate change directly affects where people live. In fact, heat-related deaths from diseases and infectious diseases are one of the most pressing risks for human health associated with a changing climate. The increase in heat and heat-related health problems is especially prevalent in cities, where the urban heat effect increases the impact of heat waves (Ward *et al*., 2016). Properly placed trees can mitigate temperatures in the forest and built environments. Not only do trees provide shade through intercepting and absorbing light, but through evapotranspiration trees actively cool the air of cities (Ward *et al*., 2016).

Roles of trees as source of food
The tree food potential
As reported by Powell *et al*. (2013) a larger percentage of all fruit cosumed by human beings are from trees, most of which come from trees that were planted. Many of these cultivated trees still have "wild" or "semi-wild" stands in "native" forest that are also harvested and which form important genetic resources for the improvement of planted stocks (Dawson *et al*., 2014). Although, quite a reasonable numbers of forest fruit tree species have been domesticated to support more efficient production, via increase in yields and quality and of course ease their harvesting.
According to FWM, (2021) forest food are keys to ensuring the availability of nutrient-dense foods and important vitamins and trace elements in many communities. They have been estimated to represent less than 0.6% of global consumption.. Forests and treesdo not meet human consumption alone but support food availability by providingfodder for domestic animals. Trees provide animal fodder, enabling communities to keep livestock that provide them with nutritionally important milk and meat. Provision of green manure that replenishes soil fertility and supports annual crop production is not left out, as well as fuelwood that provides energy (Jamnadass *et al*., 2013). In the case of fodder production, for instance, a recent initiative in East Africa involved more than 200,000 smallholder dairy farmers growing mostly introduced fodder shrubs (especially, *Calliandra calothyrsus*) as supplementary feed for their animals (Franzel *et al*., 2014). The typical increase in milk yield achieved enabled smallholders to raise extra revenue from milk sales per

cow per year and allowed them to provide more milk more efficiently to urban consumers (Franzel *et al*., 2014). Such tree-and shrub-based practices for animal fodder production increase farmers'resilience to climate change and many of the tree and other forest products are also used in ethnoveterinary treatments that support animal health and hence human food production (Jamnadass *et al*., 2013).

Food supply stabilization

Local communities derive income from timber and non-timber products (NTFPs) in forests through out the year as different fruit tree species mature at different time. In addition to providing food directly, several NTFPs harvested from natural or plantations provide a range of resources that are used by human directly or sold for income that can be used to purchase a variety of products, including food. The increased demand for forest products in low-income nations, prompted by population growth and urbanisation, provides particular opportunities to enhance rural livelihoods (Arnold *et al*., 2006).

Forest consumable food

Despite the fact that trees and other forest plants can provide edible fruit, nuts and leaves, that are often good potential sources of nutrients and are sometimes used in this regard, it does not mean that all of them are used by humans for food. There may be long lists of edible NTFPs but it does not imply that they can be consumed(Arnold *et al*., 2006).

Nuts

Nuts are a very important part of our diet in the whole world. Irrespective of one's feeding style or pattern, comsumption of nuts are are always enjoyable.They can be eatean as snacks or serve as an important component of cooking ingredients. Some of them are gotten from fruits as seed, while others grow by themselves.Some nuts support subsistence for rural communities and forest dwellers, while others, such as the *Azanzagarckeana*, Walnuts are of considerable commercial importance. Trees and shrubs bearing edible nuts are often left standing on farmlands and homesteads after land clearance (FWM, 2021).

Bushmeat

Bushmeat (wild meat), fish and insects are all be important food sources. Bushmeat is often the main source of animal protein available to forest and forest-boundary communities, serving as an important source of iron and fat, and diversifying diets (Golden *et al*., 2011). It plays a particularly important role in diet where livestock husbandry is not a feasible option and where wild fish are not available. The hunting of animals and eating of bushmeat also play special roles in the cultural and spiritual identity of indigenous peoples (Sirén, 2012).

Insects

Edible insects have been part of the human diet from time immemorial. Despite changing of feeding habits over the year, and while insect consumption was largely lost in some part of globe after the classical antiquity, the tradition lingered on in Africa. There are hundreds of insect species consumed in Africa as food or as traditional medicine. Some years ago, the FAO (Food and Agricultural Organization of the United Nations) recognized the potential of edible insects as one possibility to mitigate hunger and the effects of the climate change (Tchibozo and Lecoq, 2017).

CONCLUSION

Forest is the major components of environment, it is not only the main constituent of ecosystems but it tremendously contributes to its existence. The Forest immensely contributes to the sustainable livelihood of rural and urban dwellers and enhances environmental sustainability.

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Gold mining activities and agricultural livelihood of arable crops farmers in atakunmosa east local government area, Osun state, Nigeria

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ABSTRACT
This study examined the effects of gold mining activities on arable crop production in Atakunmosa East Local Government Area, Osun State. A 2-stage sampling technique was used to select 120 arable crop farmers using structured questionnaire. Descriptive statistics, Cost and returns analysis and Multiple regression analysis were employed to analyze the collected data. Results showed that the mean age of farmers and household size were 42.9 ± 10.1 years and 4 members respectively. Majority (93.9%) of arable crop farmers were males and had spent at least 10 years in school. Mean farm size was 17.3 acres and farmers had 10.3yeras of experience. An average arable farmer's total income losses to gold miners activities amounted to ₦17131.47 per acre per cropping season. The result indicates that yam farmers recorded the largest difference in income (₦51896.50) before and after mining activities. The coefficients of farm size, water pollution, farming experience and number of dug pits significantly influenced revenue loss of arable crops farmers. The study recommends that gold mining activities should be regulated by the government.

Keywords: Arable crop farmers, Gold extraction, Multi-stage sampling, Total income, Water pollution,

INTRODUCTION
Agriculture and mining have played instrumental roles in shaping the patterns of economic development in most countries in Africa (Ericsson and Löf, 2019). According to Alison-Madueke (2009) Nigeria is richly endowed with natural resources that are widely distributed across the country left bare, naked and untouched. Among these are; solid

minerals, petroleum and natural gas. Nigeria loses huge amount of money to illegal mining of solid mineral resources. It was alleged that two companies robbed the country of over ₦100 billion while the total loss was put at about ₦400 billion in 2017. In its effort to revive the sector, the Federal Government of Nigeria introduces a lot of reforms in the solid mineral resource sector which culminated in the 2007 Minerals and Mining Act. The Act vests entire right and control of all Mineral Resources in, under, or upon any land in Nigeria, its contiguous continental shelf and all rivers, streams and water resources throughout Nigeria, any area covered by its territorial waters or constituency and the exclusive economic zone in the Federal Government of Nigeria (Gbite, 2004).

The mining sector of the economy has been regarded as key drivers of economic growth and the development process, also has lead sectors that drive economic expansion which can lead to higher levels of social and economic well being (Bridge, 2008; Addison and Roe, 2018). In February 2017, President Muhammadu Buhari's administration published its Economic Recovery Growth plan (ERGP) 2017-2020. One of the plans was to create an enabling environment to enhance private investment targeting energy minerals, iron/steel and gold/ gemstones and decrease value leaks/loss by formalizing informal mine activities. The government plan emanated from billions of Naira that is lost annually to illegal mining activities and economic resources that are left untapped and decried the horrible state of exploited land and promised to regulate the activities of the miners (Tende et al. 2021).

Gold mining has many adverse effects which can lead to soil degradation that destroys the soil profile for agricultural production and livelihood. Agricultural farmlands were lost to gold mining activities in areas where gold mining activities are done. Mining has led to loss of agricultural farmlands in most mining areas; thereby adversely affecting farmers' means of livelihood. Apart from this, agricultural labour is moved from food production to mining thereby creating wide gap between demand and supply. Labour is being shifted from farming to mining when miners attract labourers with good pay than farmer. Mining activities also encourages leaching of soil nutrients and accelerates surface run-off. It generally leads to reduction in the overall production of farm produce in the area when there is scarcity of farmland. Contamination of surface and groundwater in gold mining communities is also a serious environmental problem in many countries, Nigeria inclusive (Aslibekian and Moles, 2003, Gilbert & Albert, 2016). Rapid deforestation including wild economic trees, reduction of soil fertility through erosion, effect on the health status of people in the mining communities which reduce the productivity of farmers. Garba (2003) and Tende et al. (2021) opined that, gold mineralization is present in alluvial and primary veins from several parts of supra crustal (schist) belts in the northwest and southwest of Nigeria. Also, most of the northwest Nigeria schist belts that have been studied are poly metallic and are endowed with mineralization such as gold (Garba, 2000). From the problems identified in the literature review, this study attempts to provide answers to the following questions: What are the economic effects of gold mining on arable crop farming in the study area? What are the effects of gold mining on arable crop farmers' production and the constraints?

The main objective of this study is to investigate the effects of mining on agricultural production Atakumosa East Local Government Area in Osun state. The specific objectives are to examine the economic effects of gold mining on arable crop farming in the study area; determine the effects of gold mining on arable crop farmers' production output and identify the constraints to arable crop production.

MATERIALS AND METHODS

The study was carried out in Atakunmosa East Local Government Area (LGA) in Osun State, Nigeria. Its headquarters are in the town of Iperindo in the east of the area at latitude of 7°30′00″North and longitude of 4°49′00″East. It has an area of 238 km² and a population of 76,197 at the 2006 census. The LGA was chosen because of the heavy concentration of gold in the area and it is part of the areas where gold mining is mainly practiced in the southwestern part of Nigeria. The climate can generally be described as tropical with two seasons - the rainy season (April – October) and dry season (November – March). The major occupation of the residents of the people is farming. Primary data used for this study were collected with the aid of well-structured questionnaire administered to the arable crop farmers in the area. Two stage sampling techniques were used in selecting the respondents. The first stage involved a random selection of 5 communities in the study area and in the second stage, 24 farmers were randomly selected from each community making a total of 120 farmers. The collected data were analyzed with both descriptive and inferential statistics. The descriptive statistic that was employed include: the mean, frequency counts, ranking and percentages while the inferential statistics that was used include: cost and returns and multiple regression technique.

- Cost and Return is specified as:

GM=TR-TVC……………………………………… (1)

Where GM = Gross Margin, TR = Total Revenue and TVC = Total Variable Cost

- Multiple regression model specification

$Y=F(X_1,X_2,X_3,X_4,X_5,X_6,X_7,et)$

The explicit equation is:

$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + e_t$ ……. (2)
Where Y= Farm income
X_1 = Farm size in hectares, X_2 = Age of respondents in years, X_3 = Years of formal education, X_4 = Household size in numbers, X_5 = Water pollution in numbers, X_6 = Farming experience in years.
X_7 = Number of dug pits, et = Error term

RESULTS AND DISCUSSION

Socioeconomic characteristics of the arable crop farmers is presented in Table 1. The result shows that the mean age of arable crop farmers was 42.9 ± 10.1years. This result implies that vast majority of the arable crop farmers are still in their economically active age. The household size of farmers indicated that their household had an average of 4 persons per household. The years of farming experience of the arable crop farmers showed that the farmers had put in about 10.28 years. This result affirms that the arable crop farmers are highly experienced in the arable crop production enterprise. Results shows revealed that the mean farm size of the arable crop farmers in the study area was 17.26 acres.
Table 1: Profile socio-economic characteristics of the arable crop

Variables	Mean	SD
Age (years)	42.9	10.1
Household size (persons)	4.0	2.0
Years spent in school (Years)	10.0	4.0
Farming experience (years)	10.28	2.07
Farm size (Acres)	17.26	6.59

Source: Field Survey, 2020

The values of the crop lost to mining activities is per cropping season in naira is shown in Table 2. The result shows that level of destruction to arable crops was highest (₦6193.97) in the plantain farms (representing by 36.2% of the total losses suffered by the arable crop farmers by the activities of the miners). Cocoyam is next to plantain with a mean income loss of ₦3614.22, constituting 21.1% of the total losses of arable crop farmers per cropping season. Arable farmers' income losses to cassava, yam and maize amounted to ₦3012.09, ₦2805.17 and ₦1506.03 respectively. An average arable farmers total income losses to gold miners activities amounted to ₦17131.47 per acre per cropping season.

Table 2: Values of crop lost to miner's activities per cropping season in Naira

Crops	Income generated from sales of crop (₦)/acre	Percentage (%)
Cassava	3012.09	17.58
Maize	1506.03	8.79
Cocoyam	3614.22	21.10
Plantain	6193.97	36.16
Yam	2805.17	16.37
Total	17131.47	100

Source: Field Survey, 2020

The effects of gold mining activities on farm income of the arable crop farmers per cropping season is presented in Table 3. The result indicates that yam farmers recorded the largest difference in income before and after mining activities with ₦51896.50 which constituting 15.5% total farm revenue. Cassava farmers was the second arable crop with mean difference of ₦38879.30 in income before and after mining activities (7.9%) while plantain had a mean difference of ₦40862.20 in income (4.0%). Maize and cocoyam suffered a mean income differences of ₦59827.60 and ₦319914.00 which constituted about 6.5% and 5.6% differences in income respectively. On average, an arable crop farmer incurred a mean difference in income of ₦238103.00 in farm income. The result of the t-test showed significant differences in income before and after mining for all the crops. These results imply that arable crop farmers' income from their farming activities is significantly reduced by the activities of gold miners in the study with the attendant consequences on their household welfare.
Table 3: Effects of gold mining activities on farm income of arable crop farmers per cropping season (n = 116)

Crops	Income before mining activities (₦)	Income after mining activities (₦)	Difference in income (₦)	Percentage loss in income	T Value
Cassava	491465.50	452586.20	38879.30	7.90	45.34***
Maize	918448.30	858620.70	59827.60	6.50	36.05***
Cocoyam	3534396.60	334482.80	319914.00	5.62	13.83***
Plantain	1013276.00	972413.80	40862.20	4.03	37.56***
Yam	335517.20	283620.70	51896.50	15.50	0.07***
Total	3113103.00	2875000.00	238103.00	7.65	

Source: Field Survey, 2020 ***Significant at 1%, **Significant at 5% level and *Significant at 10% level

that the F value (5.20) is significant at 5% level and adjusted R^2 was 0.520 indicating that the model has a good fit and a strong explanatory power. The coefficients of farm size, water pollution, farming experience and number of dug pits significantly influenced revenue loss of arable crops farmers. ($P < 0.05$). The result shows that the coefficient of farm size has positive sign and significantly affected arable crop farmers' revenue loss due to gold mining activities. A unit increase in hectare of farm size cultivated by the arable crop farmer increased the likelihood of crop losses by 1.18%. This result implies that arable crop farmers with large farm size would be willing to sell significant portion of their arable crop farm to the gold miners for gold explorative activities. In case of water pollution, the variable has a positive coefficient and significantly determined income losses by arable crop farmers. The result reveals that the more the amount of water pollutants released to the soil due to activities of gold miners and uptake by the crops to the more the enormous of revenue losses from arable crop farms. However, farming experience of arable crop farmer indicates that an additional year of experience of the farmer increased the likelihood of revenue loss as a result of gold miners' activities by 6.5%. It implies that farmers that are highly experienced in arable crop farming has the tendency of sell farmlands with declined productivity to miners for gold mining and exploration. The coefficient of the number of dug pit by gold miners increased the likelihood of revenue losses of arable crops farmers by 6.4%.

Table 4: Effects of gold mining activities on arable crop farmers' production

Variables	Coefficients	Standard error	t-value	P value
Farm size in hectares (X_1)	1.81	0.11	16.45	0.000***
Age in years (X_2)	-7.70	9.44	-0.77	0.417
Years of formal education (X_3)	-15.11	18.97	-0.80	0.427
Household size (X_4)	-40.65	348.34	-0.17	0.907
Water pollution (X_5)	1.50	0.21	7.25	0.001***
Farming experience in years (X_6)	6.49	3.25	1.99	0.051*
Number of dug pits (X_7)	6.38	2.08	3.33	0.000***
Constant	-34.70	476.87	-0.07	0.458

F value = 5.20**,R-squared = 0.543, Adj R-squared = 0.520
*significant at 1% level, ** significant at 5% level

The perceived consequences of gold mining activities on arable crop farmers in the study area is shown in Table 5. The result indicates 78.5% of arable crop farmers in the study area were faced with direct conflict with the gold miners as result of the destruction that comes from their mining activities. However, 72.4% of the arable crop farmers opined that kidnapping is a serious problem created gold mining activities and 71.9% of the farmers experienced some sort of assaults coupled with prevalent crime. Similarly, a high (64.7%) proportion of the arable crop farmers agreed that incessant murder are common serious consequence of gold mining activities in the study area. Others include, water pollution (63.8%), removal of arable crops (50.9%) and soil degradation (50.0%) that gold mining activities had triggered.

Table 5: Consequences of gold mining activities on arable crop farmers in the area

Consequences	Frequency (n = 116)	Percentage
Soil degradation	58	50.0
Water contamination	74	63.8
Removal of arable crops	59	50..9
Conflict with miners	91	78.5

Kidnapping	84	72.4
Assault	82	71.9
Murder	75	64.7

Source: Field Survey, 2020

CONCLUSION AND RECOMMENDATIONS

This study examined the effects of gold mining activities on arable crop production in Atakunmosa East Local Government Area, Osun State. The study found that majority of the arable crop farmers were literate middle-aged men, with a mean age of 42.9years. Most of the arable crops farmers had been into arable crop farming for over 10.3 years and with farm size of 17.26±6.59 acres. Average arable crop losses of farmers amounted to ₦17131.47 while the total income from arable crops was ₦238103.00 per cropping season. Farm size, water pollution and farming experience are the factors significantly determining revenue loss by arable crop farmers. The study recommends that Gold mining activities should be regulated by the government in order to minimize farm revenue loss in areas where mining activities is taking place.

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Policy Implication of Production Constraints of Adaptable Leafy and Exotic Vegetables in Southern Nigeria Agro- Ecologies

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ABSTRACT
This study identifies farmers' production constraints and preferences for leafy and exotic vegetables and the implications of policy for increased productivity. Multistage sampling procedure was used to select 200 farmers from 6 local government areas in both Oyo and Imo States. Data was analyzed using descriptive statistics. Result confirmed vegetable farming as an important agribusiness enterprise that offers opportunities especially for the young and unemployed youth. To fully tap the economic benefit of vegetable production, it is recommended that government's ongoing policy drive give vegetables much greater priority than is currently receiving.

Key words: Leafy vegetable, Exotics,Production Constraints ,Southern Nigeria

INTRODUCTION
In Nigeria, agriculture remains the largest sector that contributes to the nations Gross Domestic Product (GDP). The sector contributed an average of 24% to the nation's GDP over a seven period ,(2013 – 2019 (Taiwo, 2020 and between January and March 2021, the agriculture sector contributed 22.35 percent of the total GDP (FAO/David Tsokar 2022). Agribusiness is a large part of Nigeria's economy, directly providing more than 50 percent of jobs and contributing more than 35 percent to the national GDP. It has enormous potential for transformation because primary agriculture is much larger than off-farm agribusiness. Primary agriculture accounts for 21 percent of the national GDP,whereas off-farm agribusiness contributes 14 percent.

As the largest employer of labour in the country, the sector employs more than 36% of the country's labour force. More than 80% of Nigeria's farmers are smallholder farmers and accounts for 90% of Nigeria's agricultural produce. Crop production remains the largest segment and it accounts for about 87.6% of the sector's total output. This is followed by livestock, fishing and forestry at 8.1%, 3.2% and 1.1% respectively (Taiwo2020) .Vegetables can generate higher profits than staple crops, especially when land is relatively scarce and labour is abundant (Ibeawuchi *et al.*, 2015).

Over the last 20 years, value-added per capita in agriculture has risen by less than 1 percent annually, with the effect of rising food and raw materials import bills and declining levels of self-sufficiency in food production. Low mechanization of agricultural production and technologies appropriate for small, medium and large scale farming remains an important challenge to greater productivity, especially in enhancing agricultural extension delivery system. There is low capacity building and poor enlightenment of farmers to achieve mass acceptance and adoption of modern technology in farming. In addition, budgetary allocations to the agro- sector does not encourage enough production to guarantee increased food production and sufficiency in the country. The share of Agriculture in Federal Government's annual budget has consistently fallen below the Maputo Declaration of 10% share of total country budget for agriculture, an indication of the low priority previous governments had placed on agriculture. Out of the total 2020 budget size, agriculture budget represents 1.8% (or N183 billion) of the total 2020 budget size.
In spite of the performance of the agricultural sector in recent times, productivity remains low when compared with the global average. There are however enormous opportunities to design policies and investments to accelerate transformation and create more and better jobs. The current National Agricultural Technology and Innovation Policy (NATIP), 2022- 2025 is designed to fast track the agricultural revolution in Nigeria. The policy is expected to boost extension service delivery, create access to finance, ensure the security of Agricultural land and other related investments that are Agro- based.

METHODOLOGY

The study was carried out in the south eastern and western part of Nigeria. A multi-stage sampling procedure was used. The first stage involved the selection of one state from South West (Oyo) and Imo State from South East. In the second stage, local government areas prominent in vegetable production.in the states were selected. The third stage was the selection of villages from the identified Local Government Area (LGA). In the final stage, vegetable farmers were randomly selected and interviewed with the aid of semi -structured questionnaires. The Participatory Rural Appraisal (PRA) technique was also used to evaluate constraints. Analysis of data collected was done using descriptive statistics.

RESULTS AND DISCUSSION

Socio-economic characteristics

With respect to sex, in the study area, there are more women than men in vegetable production. The average household size of vegetable farmers is 9 members and this implies that there is enough family labour for vegetable production. The significance of household size in smallholder agriculture, hinges on the fact that, the availability of labour, total area cultivated, the amount of farm produce retained for domestic consumption, and the marketable surplus are all determined by the size of the farm household. Farming is the primary occupation and main source of livelihood most respondents.

Enterprise characteristics

Farm size cultivated by most farmers is between 1- 2.5 acres as they operate basically as smallholders while the mean farm holding is 1.24 acres. Years of farming experience is a main factor in agricultural productivity. The mean farming experience is 13 years.
In the study area, land ownership structure is mostly through inheritance. Land ownership structure indicate that land is mostly owned by men .With respect to land topography ,most cultivatable land for vegetable production is within the valley bottom in the Imo while most land area in the Oyo, are flat grounds.

Farming Systems

In both Imo and Oyo states, the main farming system practiced is mixed cropping production. Farmers also keep livestock like poultry, sheep, and goat. Maize and cassava are the crops that are usually inter-cropped with vegetables. This diversification into different crops is done to mitigate the risks of crop failure. While most farmers make use of the natural rain as the main source of water, a few use irrigation system in addition to rain to complement water requirements on the farm. Those with farms located close to the river use pumps to channel water into the fields.

Farmers have access to and cultivate different types/ varieties of indigenous leafy vegetables and exotics .Vegetable planted in the Imo state (South East), include Telfaria, Okra, Amaranth, Cucumber and Watermelon. Also planted are bitter leaf and water leaf. In Oyo State (South West), vegetables grown include Okra, Amaranth, Celosia, Corchorus, as well as cucumber and watermelon. The exotic ones include cucumber, cabbage, lettuce and watermelon. In both states, improved varieties of these vegetables are sourced mainly from retail seed outlets.

There are various factors that influences choice of vegetable varieties produced. Some vegetable are planted for their leaves and others for their fruits. In Oyo state, most farmers still grow more of the traditional vegetables still available since most of the consumers preferred these ones to the newly introduced varieties. In Imo State, farmers reported that egg plants with small size fruits often exhibit more tolerance to pest and disease. As such, a nursery is usually cultivated and seedlings are drawn from there to replace dead or diseased plants on the field. Similarly, consumers of okra in Okigwe, Imo state were not bothered by the outward appearance of the fruits (such as fruits being spiny or not) as the most preferred trait is viscosity, whereas in Orlu senatorial zone, spineless and size of okra is a big determinant of acceptability and consumption. The farmers in these areas therefore cultivate vegetables with preferred traits.

The farmers in Imo state use inorganic fertilizers and manure to boost the soil fertility but those in Oyo (specifically in Igagan/Ibarapa) do not use inorganic fertilizer at all. They however have dedicated areas for cultivation of vegetables alone. Most vegetable farmers in across the all agricultural zones plant vegetables for their leaves. The methods of storage are mostly traditional.

Constraints Analysis

Land ownership

A key constraint is agricultural production in Nigeria generally, is the absence of a clear title to land. Group ownership of land is associated with such problems as limited tenure security, restrictions on farmers' mobility, and the inevitable fragmentation of holdings among future heirs. This also limit access to formal credit, since the farmer cannot use land as collateral. There are however some land owned by government which is sometimes leased out to farmers.
The pattern of land ownership for vegetable farmers is basically by inheritance. This followed by ownership through rentage or lease while few percentage of the cultivated land is acquired through outright purchase. Because most vegetable farmers are poor and without customary access to inherited land, they cultivate and remain on depleted lands and further degrade these resources leading to declining productivity.

Fertilizers usage

Although improved crop varieties exist, low fertilizer use is a serious constraint to agricultural productivity growth. An important factor is low and unstable domestic production. There has been no domestic production of fertilizer since the early 2000s. Other issues which affect domestic supply of fertilizer, even till date, include high transport costs from port to inland destinations, poor distribution infrastructure, the absence of capital for private sector participation in distribution, significant business risks facing fertilizer importers, and inconsistencies in government policies. As a result, most vegetable farmer use animal waste as fertilizer because it is relatively cheap and readily available. Some farmers also use NPK and urea. Only very few use organic folia fertilizer.

Access to water

Challenges faced by vegetable farmers in Imo (SE) and Oyo (SW) states in particular is the problem of inadequate water due to irregular rainfall pattern as agriculture in these parts of the country is still majorly rain-fed. Other challenges which cuts across all the zones include insect/pest infestation, inadequate access to information, limited access to improved varieties and inadequate access to finance.

Access to extension services

The extension workers are important stakeholders in the farming community as they are the middlemen responsible for taking farmers concerns to the researchers just as they take developed technologies to the nooks and crannies of the farming communities. Most respondents had no access to extension services and this is a major constraints to farmers' productivity in general and to vegetable in particular.

Access to credit

As is the case with all businesses, farming activities or agribusiness require money. Access to agricultural credit is positively linked to agricultural productivity. Most farmers do not have access to formal credit facilities and this remains a major limiting factor even in vegetable production.

Banks with large loan funds are generally difficult for smallholder farmers to access. Problems of collateral and high interest rates appear to frequently screen out most potential rural smallholder beneficiaries.Apart from high rate most these farmers are practicing subsistence farming, with low income. That is, they are very poor and lack assets that can be used as collateral for accessing required amount enough to boost their productivity. Besides, farming is full of risk that rendered it not suitable for conventional loan repayment policy. Agricultural loans are often short-term with fixed repayment periods, a loan structure that is not suitable for annual cropping or livestock production.

Sources of credit
Most do not belong to any farmers' cooperative mainly as a result of lack of trust As such, purchase of improved seeds, land clearing, purchase of fertilizes and agrochemical and others expenses is done using personal money. The few that are members of a cooperative, are able to do so, access credit through informal sources like cooperatives and friends, and those that source credit from banks and micro finance houses are very few.

Incidence Pest and disease
Farmers in both states experience similar vegetable insect/pest infestation. The common insect pests are grasshoppers, white flies and podagrica spp, resulting in stunted growth of affected plants. The infested plants are usually removed and buried.

Climate changes
Apart from man-made constraints, farmers' output and income were also negatively affected by climate. Changes in weather affected planting period. Different coping strategies were employed by farmers in order to cope with changes in the climate. These included use of irrigation, planting of improved drought -tolerance plants and changing of planting and harvesting times.

CONCLUSION

Vegetable farming is a major enterprise among smallholder farmers as well as opportunities for attracting the young and unemployed if cultivatable lands, inputs, credit and social overheads that will make the farming communities liveable are provided.

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Farm households' response to beef price increase in Tai Local Government Area of Rivers State: A case of COVID-19 era.

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ABSTRACT

The study investigated farm households' response to beef price increase in Tai Local Government Area. Data were collected from 83 respondents drawn from the study area using multi-stage sampling techniques. A set of structured questionnaires were used for the study. Data were analyzed using descriptive statistics and 4-point likert scale. The findings of the study showed that 38.6% of the sampled respondents were within the age of 40-49 years. About 80.7% of the respondents were males while, 19.3% were female and 71.1% of the respondents had household size of 1- 4 persons while 28.9% of them had household size of 5-10 persons. Findings from the study also showed that 87.95% used periwinkle, 97.59% used fish, as alternative source of protein to beef. The major factors which were responsible for price increase of beef during the pandemic; lockdown; transportation cost, high cost of production and few suppliers/inadequate supply of beef. The study recommended that at moments of lockdowns, government should give free and uninterrupted passage to agricultural commodities across the country so that prices of these commodities will not increase drastically.

Key words: Farm household, Beef, Protein, Price increase

INTRODUCTION

Beef is a major source of protein in an average Nigerian family. This is necessitated due to its wide acceptability devoid of religious and sociocultural constraints (Oladejo, 2012). The supply of cattle and its product have been declining while the demand has been increasing. The short fall in supply of cattle has often been linked to the high cost of cattle marketing, because the cattle are brought from the northern part of the country to the South, usually there is high cost of transporting the cattle considering the long distance that the traders have to travel with them (Mafimisebi *et al*., 2013). More worrisome, is that the advent of COVID-19 has further led to an increase in the price of beef. According to FAO (2021) World food commodities prices such as vegetable oils, meat (including beef), cereal is reducing global food demand after COVID-19 outbreak compared to the pre-COVID-19 period when people spent more on food.

COVID-19 poses as a threat to food systems as it reduces food supply and increases the price tagged to foods (Egwue *et al.,* 2020). Meat and livestock prices have been extraordinarily volatile during the COVID-19 pandemic (Lusk *et al*., 2020). The volatility and rise in the price of meat/beef could threaten household food security as wages and income remain unchanged (Obaye *et al.*, 2020). An average man/woman is supposed to consume 10-30% of calories from protein sources daily (Yvette, 2020). With the tediousness of farming activities, household farmers would require sufficient amount of protein if they must carry out their farm operations effectively. Schönfeldt *et al.*, (2013) observed that an insufficient supply of nutrients to the human body restricts and retards physical and cognitive development, and both manifest as financial and social burdens on society. Furthermore, they mentioned that animal source foods are valuable sources of complete, high-quality, easily digestible protein and many essential micronutrients such as iron, zinc, calcium, vitamin A and vitamin B12. Thus, in the face of rising beef prices owing to the incidences birthed by the COVID-19 pandemic, farm households who consume this commodity may have to look for alternative protein sources if they must meet the sufficient amount of protein required to carry out their farming operations. On this standpoint, the study was poised to analyze the following objectives:

i. describe the socioeconomic characteristics of the farm household heads;
ii. ascertain the substitutes to beef;
iii. identify factors that were responsible for price increase in beef during the pandemic.

MATERIALS AND METHOD

The study was conducted in Tai Local Government Area (LGA), Rivers State Nigeria. Tai has an area of 159km^2 and a population of 117,797 and a projected population of 142,602 in 2011 (NBS, 2012; NPC, 2006). The LGA lies between latitudes 4° 43' and 7° 18'N of the equator and longitudes 4.72°and 7.30°E of the Greenwich Meridian. The LGA is within the tropical climate and experiences two distinct seasons, the rainy season and the dry season. The primary occupations are farming, and fishing to a lesser degree.

Multi-stage sampling was used in selecting the sample size of the study. In the first stage, the purposive selection of ten (10) communities out of the seventeen (17) communities in Tai LGA was employed. This was owing to the fact that there were more farmers concentration in the selected communities because they engage more in farming, The second stage involved the simple random selection of ten (10) household heads (household heads was the medium of contacting the farm households) from Botem, Kpite,, Korokor, ueken, Bunu and Nonwa, eight (8) was chosen from Sime and five (5) from Kira, Borobara and Gbene-ue, thus making a total of 83 respondents.

METHOD OF DATA ANALYSIS

Objectives (i) and (ii) were achieved using descriptive statistics. Objective (iii) was achieved viz., 4 point Likert scale.

Likert Scale Rating Technique

Likert scale rating technique was used particularly in measuring the factors that were responsible for price increase in beef under the pandemic. This was done on a four-point basis. According to Umoinyang (2014) the 4-point scale rating technique does not give room for the respondents to be indifferent. The rating is presented in the following order:

Strongly agreed (SA) = 4; Agreed (A) = 3; Disagree (D) = 2; Strongly disagree (SD) = 1.

The mean scores of the respondents based on the 4-point scale will be 4 + 3 + 2 + 1 = 10, 10/4 = 2.50. Using the interval scale of 0.05, the upper limit cut-off point will be 2.50 + 0.05 = 2.55. The lower limit was 2.50 – 0.05 = 2.45. On this basis, any mean score (MS) below 2.45 (i.e. MS < 2.45) will be regarded as not important. Those between 2.45 and 2.55 will be considered as important (i.e. $2.45 \geq MS \leq 2.55$). Mean score greater than 2.55 (MS>2.55) will be considered very important.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

Table 4.1 shows that majority (38.6%) of the farmers were of the age range of 40-49 years and 36.1% of them were within the age 30-39 years of age. This finding agrees with the argument of Ogundari and Ojo (2005) who mentioned that middle aged people constitute the working force of the populace (31-50 years) as they are still active in terms of agricultural production and marketing. Entries on sex shows that 80.7% of the respondents were male while 19.3% of them were female. It therefore implies that most males were faced with responsibility of catering for their families. Meanwhile, results on household size shows that 71.1% of the respondents had household size of 1-4 persons while 28.9% of them had household size of 5-10 persons. Furthermore, results from table 1 demonstrates that, 4.8% of the respondents had no formal education, 9.6% of them had primary education, 72.3% of them had secondary education and 13.3% of them had tertiary education, establishing that a good proportion of them are educated. Education accounts for why farmers are able to manage their finances since education facilitates the capacity of individuals to understand, manage, and work with new ideas (Ewuola and Ajibefun, 2000). On income, result shows that 67.5% of the respondents earned 5000 – 10000 naira per week while 32.5% of them earn 11000 – 15000 naira per week. On this premise, it is less debated that household consumption pattern can be enormously influenced by their income levels. Entries on Marital status shows that 55.4% of the respondents were married, 8.4% of them were divorced, 24.1% of them were widowed and 12% of them were single. Results on the type farming indicated that 96.4% of the respondents engaged in crop cultivation while 3.6% of reared livestock. Showing that the study area would poses more crop produce than livestock.

Table 1: Frequency distribution table showing summary statistics of respondents according to their socio-economic characteristics (n=83)

Variables	Categories	Frequency	Percentage(%)	Mean
Age (years)	30 – 39	30	36.1	
	40 – 49	32	38.6	44.5yrs
	50 – 59	12	14.5	
	60 and above	9	10.8	
	Total	**83**	**100**	
Gender	Male	67	80.7	
	Female	17	19.3	
	Total	**83**	**100**	
Household size	1 – 4	59	71.1	
	5 – 10	24	28.9	4 persons
	Total	**83**	**100**	
Education	No formal education	4	4.8	
	Primary education	8	9.6	
	Secondary education	60	72.3	
	Total	**83**	**100**	
Income (₦)	5000 -10000	56	67.5	
	11000 -15000	27	32.5	₦9289.16
	Total	**83**	**100**	
Marital status	Married	46	55.4	
	Divorced	7	8.4	
	Widowed	20	24.1	
	Single	10	12.0	
	Total	**83**	**100**	
Farm type	Crop	80	96.4	
	Livestock	3	3.6	
	Total	**83**	**100**	

Source: Field survey 2021

Alternative sources of protein by farm households

The alternative sources of protein by the farm households served as a response to the increase in the price of beef, the result is presented in Table 2 which shows on that basis of frequency that 30 of the respondents ate pork as substitute to beef, 47 of them ate chevon (Goat meat), 49 of them ate bush meat, 76 ate crayfish, 73 of them ate periwinkle, 81 of them ate fish, 33 of them ate chicken and 43 of them ate snail. The results above indicate that majority of the respondents ate fish as their alternative source of protein during COVID-19 owing to the high cost of beef Special attention is given to fish product consumption as a meat substitute because fish products are important sources of protein (Jione and Won, 2002).

Table 2. Frequency distribution of respondents according to their substitutes to beef

Items	Frequency	Percent
Pork	30	6.84
Chevon	47	10.76
Bush meat	49	11.21
Crayfish	76	17.39
Periwinkle	73	16.70
Fish	81	18.45
Chicken	33	7.55
Snail	48	10.98
Total	**437**	**100.00**

NB Multiple response (i.e. respondents were allowed to choose one or more answers from the list)
Source: Field survey, 2021

Factors for Increase in Beef Price during COVID-19 Pandemic

The factors that influenced the supply of beef as identified by the respondents were ranked as shown in table 4.3. Lockdown, transportation cost, high cost of purchase and few suppliers/inadequate supply of beef were agreed by respondents to have influenced beef supply (with mean scores greater than 2.50). On the other hand, respondents disagreed that future expectation (with mean score 2.00) of prices had influence on beef supply. This result, agrees with the submission of Serpil and Mehmet (2020) who asserted that rise in food prices under the COVID-19 outbreak was related to lockdown restrictions

Table 3: Factors that influenced beef supply during the pandemic

S/NO	FACTORS	SUM	MEAN	REMARKS
1	Lockdown	327	3.94	Agree
2	Transportation cost	253	3.05	Agree
3	High cost of purchase	254	3.06	Agree
4	Few suppliers/inadequate supply of beef	253	3.00	Agree
5	Future expectation	166	2.00	Disagree

Criterion mean score ≥ 2.50
Source: Field survey, 2021

CONCLUSION AND RECOMMENDATIONS

The study showed that the widely used substitute to beef by farm households in the study area during COVID-19 was fish and that lockdown was the most prevailing factor which influenced increase in the price of beef in the COVID-19 pandemic.

On the basis of the findings, the study made the following recommendation:

i. At moments of lockdowns, government should give free and uninterrupted passage to agricultural commodities across the country so that prices of these commodities will not increase drastically.

ii. Government should encourage fish production as it serves as a veritable substitute to beef.

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Determinants of Artisanal Fishermen Access to Micro-Credit in Andoni Local Government Area, Rivers State, Nigeria

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ABSTRACT

This study examined the determinants of artisanal fishermen access to micro-credit in Andoni L.G.A of Rivers State. About 90 artisanal fishermen were sampled in the study area. Logistic regression and descriptive statistics e.g. frequency, simple percentage, mean ratings were employed as data analysis techniques. The results showed that 67.78% (more than half of the sample) of the respondents were male, 82.22% were married and 56.67% completed secondary education The findings also showed that the sampled the respondents affirmed that deposit money banks, microfinance banks, cooperative societies, local money lenders, government agencies and friends and relatives were sources of micro-credit. The results showed that collateral requirements and availability of loan guarantor increased the probability of micro-credit access by 5.67% and 4.96% respectively. Similarly, it was found that each additional year of age and educational qualification increased the probability of micro-credit by 1.66% and 2.29% respectively. The results, however, showed that the interest rate charged and years of farming experience decreased the probability of micro-credit access by 0.128% and 5.2% respectively. Based on the findings, it was recommended that the government should ensure that banks and other micro-lending agencies do not impose difficult collateral conditions and high interest rates on micro-credits to enable artisanal fishermen to increase their funding for higher productivity.

Keywords: **Artisanal fishermen, micro-credit, cooperative societies, money lenders and government agencies**

INTRODUCTION

There has been a growing interest in improving the access of small-scale farmers including artisanal fishers to micro-credit in developing countries. This is part of the efforts to address their credit needs and constraints so as to improve their access to credit. Essentially, access to micro-credit has been described as the strategy to improve the financial inclusion of small-scale and low-capital farmers. According to Offor *et al.* (2021), micro-credit is imperative for meeting the financial needs of the poor as they do not have the required collateral conditions for borrowing from the conventional financial institutions. Thus, micro-credit is fundamental in helping the low-capital and poor-technology smallholder farmers to improve their financial position. Access to microcredit connotes the ability and willingness to borrow and repay the lender at the price that will cover his cost (Mukherjee, 2014). It reflects how comfortable an individual or enterprise can make optimal use of the financial services (Gehringer, 2014).

The concept of microcredit or microfinance development is based on the fact that the poor possesses the ability to generate wealth through the "income generating economic activities" but is handicapped by the lack of credit, savings and insurance facilities. Okidim and Obe-Nwaka (2021) posit that micro credit access by small-scale fish farmers are being encouraged through the formation of co-operatives to improve their access to micro-credit. This is also expected to provide opportunities for increased and affordable access to credit for profitable growth. Dzadze *et al.* (2012) described access to micro-credit as a fundamental resource that creates opportunity for farmers to expand their agriculture activities or adopt innovative farming methods through the use of new technology. The lending procedures provided by the formal financial institutions have limited the access of farmers to credit. This tends to pose a threat to the process of agriculture development.

Furthermore, Kolapo *et al.* (2021) observed that the availability of credit is essential for the development of the agriculture sector. They further explained that the socioeconomic characteristics of the farmers are the important determinants of their access to credit. In addition, Emerole et al. (2013) identified years of farming experience, membership of cooperative society and savings of farmers as the factors that determine their access to credit. While Obisesan (2009) outlined age as the major determinant of credit access, Ololade and Olagungu (2013) as well as Okidim and Obe-Nwaka 2021 argued that high interest rate and delay in government loan approval are the factors that determine micro-credit access among rural farmers. It is also argued that improvement in the micro-credit access procedure among small-scale farmers as well as their prompt access to credit facilities have the potential of fostering the productivity capacity of small-scale fish farmers. Udoka, Bassey and Okorie (2019) argued that income is an important consideration in credit access because lower income earners rarely save and as such do not have tangible assets that can be mortgaged as security for loan.

Okidim and Obe-Nwaka (2021) investigated access to micro-credit acquisition among small-scale fish farmers in Obio-Akpor Local Government Area of Rivers State, Nigeria. Descriptive statistics and multiple regression analysis were used in data analyses using semi-structured questionnaire. The findings showed that majority of the respondents are male (65.0%), 35.0% were between 20 – 30 years, 71.0% were married and 94% had formal education. The results further showed micro-credit from cooperative societies is an important source of finance for majority (47.0%) of fish farmers. The result of the multiple regression analysis showed that sex, household size, fish farming experience and income were determinants of micro-credit acquisition. The results further revealed that high interest rate charged, delay in processing loan application and age, farm size, lack of awareness/proper communication and insufficient available credit and experience are major constraints to micro-credit acquisition among the fish farmers. Based on the findings, the study recommended that financial institutions should provide single digit interest rate for fish farmers. Despite the efforts geared at improving the access of artisanal fishermen to micro-credit, there has been growing controversies on the factors that determine their access to credit. While majority of the argument identify the socioeconomic characteristics of the artisanal fishermen as major factors affecting their access to micro-credit, it is also argued that interest rate, government policy and collateral conditions of lending institutions among others are determinants of micro-credit access by artisanal farmers. As the controversy continues to grow, this study sets out to assess the determinants of artisanal fishermen access to micro-credit in Andoni LGA, Rivers State.

1.2 OBJECTIVE OF THE STUDY

The broad objective of this study is to assess the determinants of artisanal fishermen access to micro-credit in Andoni LGA, Rivers State. However, the specific objectives were to:

i. describe the socio-economic characteristics of the artisanal fishermen in Andoni LGA.
ii. determine the sources of micro-credit among artisanal fishermen in the study area.
iii. examine the determinants of micro-credit access among artisanal fishermen in the study area.

METHODOLOGY

Study Area

The study on determinant of fishermen access to Micro credit was conducted in Andoni Local Government Area in Rivers State. The LGA was created in the year 1991with its headquarters located at Ngo town. It has a land area of over 233 km^2 and an estimated population of 311,500 people as at the last census. (NPC, 2006). The postal Code is 504, and coordinate of 4.487N, 7.4087E. Andoni LGA has a latitude of 4028121.811 North and a longitude of 7022157.511 East, 4° 32′ 57″ north, 7° 26′ 47″ East. Geographically, Andoni LGA shares boundaries on the North with Khana LGA, on the South with the Atlantic Ocean, on the East with Opobo/Nkoro LGA and on the West with Bonny LGA. The Local Government Area has many towns, villages and Fishing settlements which are either separated from each other by seas, rivers, creeks and as well as land boundaries. The popular economic activities for the people of Andoni LGA include Artisanal fishing and farming. (Okuduwor, Oretan and Morris 2022).

Research Design

In this study, survey research design was employed. According to Collis and Hussey (2003), survey research design is imperative for gathering data, study sample and generalizing the findings obtained to the entire population.

Population of the Study

The population of the study comprised all the artisanal fishermen in various fishing communities in Andoni LGA.

Sampling Procedure and Sample Size

A multi-stage sampling technique was employed to purposively select four (4) fishing landing settlements/communities that are known for artisanal fishing activities. They were: Oyorokoto, Ekede, Ebukuma and Asarama. Random sampling method was used to select 20 fishermen from each settlement/community and 30 from Oyorokoto to give a total of 90 respondents. This formed the sample size for the study.

Data Collection

The data required for this study were collected using well-structured questionnaire.

Data Analysis

Descriptive statistics, mean rating and logit regression were used to measure the objectives percentage distribution, logit regression was applied to estimate the likelihood of micro credits acess based on the socio-economic determinants. Logit regression method was applied because the dependent variable (Access to micro credit) was measured as a discrete variable and depicts non linear relationship.

The model specification is:

$Y = bo + b1X_{1,+} b2X_{2,+} B3X_{3\,,+} B4X4_{,+} B5X_{5\,+,}B_6 + X_{6,+}B_{7+}X_{7\,+,}B8X8 + B9X9_{,+} B_{10}X_{10} + U_t$ .equ 1

Where: Y = Access to Credit, X_1 = Interest Rate, x_2 = Ownership Of bank account, x_3 = Membership of cooperative society, x_4 = Years of farming experience, x_5 = Collaterial requirements, x_6 = Ownership of fishing boat, x_7 = Availability of laon guarantor, x_8 = Type of occupation, x_9 = Age and x_{10} = Education, ut = error term

The formal specification of the logistic regression model is as follows

$\ln\{P_j/(1-P_j)\} = \alpha + \alpha_1x_1 + \alpha_2x_2 + \alpha_3x_3 + \alpha_4x_4 + \alpha_5x_5 + \alpha_6x_6 + \alpha_7x_7 + \alpha_8x_8 + \alpha_9x_9 + \alpha_{10}x_{10} + U_t$ (3.2)

Where: $\ln\{Pj/(1-Pj)\}$ = natural log of the odds in favour of access to micro-credit, α = constant parameter, $\alpha_1 - \alpha_{10}$ = vector of coefficients of the factors of access to micro-credit, $x_1 - x_{10}$ = determinants of access to micro-credit and U_t = error term

RESULTS AND DISCUSSION

2.1 Socio-economic Characteristics of Respondents

The socio-economic characteristics of the respondents were shown in Table 1

Table 1.: Socio-Economic Characteristics of Artisanal Fishermen in Andoni LGA

Variables	Freq. (n =90)	%	Cumulative %
Sex			
male	61	67.78	67.78
female	29	32.22	100
Total	90	100	
Age (Years)			
18_25	1	1.11	1.11
26_31	8	8.89	10
32_40	21	23.33	33.33
41_45	26	28.89	62.22
46_50	19	21.11	83.33
51_65	10	11.11	94.44
66_and_above	5	5.56	100
Total	90	100	
Marital status			
single	8	8.89	8.89
Married	74	82.22	91.11

widow/widower	3	3.33	94.44
Divorced	5	5.56	100
Total	90	100	
Educational attainment			
No formal education	9	10	10
Primary	12	13.33	23.33
Secondary	51	56.67	80
Tertiary	18	20	100
Total	90	100	
Household size			
1_3	22	24.44	24.44
4_5	29	32.22	56.67
6_and_above	39	43.33	100
Total	90	100	
Annual income (N)			
Less_than_100,000	30	33.33	33.33
100,000_150,000	28	31.11	64.44
151,000_200,000	13	14.44	78.89
Above_200,000	19	21.11	100
Total	90	100	

Source: Field Survey 2022

Table 1. shows the socioeconomic characteristics of artisanal fishermen in Andoni in Rivers state, bellow are some of the socioeconomic characteristics.

Sex:

The results showed that about 67.78% (about 61 respondents) and 32.22% (29 respondents) were males and females respectively. In other words, more than half of the respondents were males, implying that artisanal fishing is a male dominated business. The study portrayed that males are more involved in the means of livelihood of the family. This is in line with the findings of Okuduwor, Oretan and Morris (2022) which showed that artisanal fishery in Andoni LGA is dominated by the male folks. Okidim and Obe-Nwaka (2021),

Age:

The results in table 4.2 also showed that about 1.11% (1 respondent), 8.89% (8 respondents) and 23.33% (equivalent 21 respondents) were between the ages of 18 and 25years, 26 and 31years and 32 and 40years respectively. The results further showed that about 28.89% (i.e26 respondents), 21.11% (equivalent 19 respondents) and 11.11% (about 10 respondents) were between the ages of 41 and 45years, 46 and 50years and 51 and 65years respectively. It was also found that about 5.56% (5 respondents) of the respondents were 66years and above. In summary, the results showed that majority of the respondents were between the age group of 41 and 45years. The economic implication of this result/ findings is that the age bracket fell within the work force and the fishermen were still energetic and highly productive .The result agrees with the findings of Okuduwor et al (2022) that ascertains that farmers between the ages of 30-49 years are willing and able to take risks with the expectations of a larger profit than old farmers.

Marital Status:
It was evident from the results that about 8.89% (8 respondents), 82.22% (equivalent 74 respondents) and 3.33% (equivalent 3 respondents) were single, married and widow/widower respectively. The results further showed that 5.56% (5 respondents) were divorced. In other words, the results showed that majority of the respondents were married. The result aligns with the findings of Okuduwor et al (2022) that married people constitutes the larger population of artisanal fishing business in Andoni LGA of Rivers State and Okidim and Obe-Nwaka (2021) that majority of the fishermen in their study area were married and would therefore have greater family responsibility.

Level of Education: The results from Table 1 above further showed that about 10.00% (9 respondents) of the respondents do not have access to formal education. It was also found that about 13.33% (12 respondents), 56.67% (51 respondents) and 20.00% (18 respondents) completed primary, secondary and tertiary education respectively. The study showed that majority of the respondents having access to secondary education is an implication that Micro credit lending agencies tend to consider level of education in granting loans. In summary, the results showed that more than half of the sampled respondents completed secondary education contradicting the findings of Okuduwor et al (2022) that majority of the artisanal fishermen in Andoni LGA had access to only Primary education.

Household Size:
Table 1.2 as well showed the household size of the respondents and it was found that about 24.44% (22 respondents) and 32.22% (29 respondents) had family size of 1 to 3 persons and 4 to 5 persons respectively. The results further showed that about 43.33% (39 respondents) had family size of 6 persons and above implying not too large household sizes. In summary, the distribution of the households based on their sizes showed that most of them have households of about 6 persons, an indication that family labor is beneficial in artisanal fishing. This result agrees with Okidim and Obe-Nwaka (2021) that fishing families with large households will not have to spend much on hiring laborers.

Annual Income
As observed from Table 1.2 about 33.33% (30 respondents), 31.11% (28 respondents) and 14.44% (13 respondents) had annual income of less than NGN100,000, between NGN100,000 and NGN150,000, and between NGN151,000 and NGN200,000 respectively. The results further showed that about 21.11% (equivalent to 19 respondents) had annual income of more than NGN200, 000. In summary, the results showed that the annual income of majority of the respondents about NGN100, 000 net income ie after household consumption and expenditure This suggests that most of the respondents were low-income earners because artisanal fishing in Andoni LGA o is a low income-earning means of livelihood, corresponding with the findings of Okuduwor et al (2022). Although, artisanal fishing is a means of livelihood

Table 2 Analysis of the respondents views on sources of micro-credit

Sources	SA	A	D	SD	Mean Score	S.D
Deposit Money Banks	41	32	12	5	3.21	0.88
Microfinance banks	23	34	23	10	2.77	0.958
Cooperative societies	38	43	9	0	3.32	0.650
Local money lenders	47	32	7	4	3.36	0.812
Government agencies	23	23	22	21	2.54	1.119
Non - Government organizations	3	19	28	40	1.83	0.877

Friends and Relatives	51	30	6	3	3.43	0.765

Source: Field Survey 2022

From table 2 the results showed that the respondents affirmed that deposit money banks, microfinance banks and cooperative societies were sources of micro-credit. This is based on the fact that the corresponding mean scores of these sources were greater than the critical mean value of 2.5. It is also evident from the results that the respondents agreed that local money lenders, government agencies and friends and relatives were sources of micro-credit. This is established from the corresponding high mean scores (3.36 and 3.43) which are greater than the critical mean value of 2.5. In summary, the findings showed that the major source of micro-credit to artisanal farmers was friends and relatives given that it had the highest mean score of 3.43. It therefore followed from the results that majority of the artisanal farmers rely on informal financial sources for funding. This implies that the volume of credit might be low compare to other sources.

Table 3: Summary of the respondents' Perception on determinants of access to microcredit

Determinants	SA	A	D	SD	Mean Score	S.D
Interest rate charged	30	33	11	16	2.911	1.002
Ownership of bank account	44	28	14	4	3.244	0.878
Membership of cooperative society	14	37	33	6	2.655	0.823
Years of farming experience	19	63	6	2	3.1	0.601
Collateral requirements	32	46	10	2	3.2	0.722
Ownership fishing boat	66	19	4	1	3.67	0.618
Availability of loan guarantor	78	10	2	0	3.84	0.422
Type of occupation	21	21	36	12	2.57	0.995
Age	12	21	40	17	2.31	0.932
Educational Qualification	6	7	9	68	1.47	0.927

Source: Field Survey 2022

Table 3 above, shows the determinants of access to credit with critical mean value of 2.5. However, it was established from the results that the respondents failed to agree that age and educational qualification were determinants of access to micro-credit amongst artisanal fishermen. Overall, availability of loan guarantor was identified as the major determinant of loan access given that it is associated with the highest mean score of 3.84. This agrees with the findings of Obe-Nwaka, Okidim and Agbagwa (2020) The findings showed that interest rate charge decreased the probability of micro-credit access among artisanal farmers in the study area.

Table 4 Summary of logic regression results for micro-credit access determinants

Regressor	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Interest rate charged	.9828921	.358586	-0.05	0.962*	.4807989	2.009316
Ownership of bank account	1.780481	1.0771	0.95	0.340	.543994	5.827475
Membership of cooperative	1.1555	.5394653	0.31	0.757*	.4627771	2.885149
Years of fishing experience	.4991381	.3786942	-0.92	0.360	.1128281	2.208128
Collateral requirements	2.14689	1.336668	1.23	0.220	.633645	7.274006
Ownership of fishing boat	.6202197	.3296131	-0.90	0.369	.218866	1.757571
Availability of loan guarantor	1.950771	2.251149	0.58	0.563*	.2032063	18.7273
Type of occupation	.7365212	.2806922	-0.80	0.422	.3489698	1.554471
Age	1.249751	.5932789	0.47	0.639*	.4928822	3.168866
Educational Qualification	1.361377	.5153899	0.81	0.415	.6482321	2.859079
_cons	.0026636	.0165822	-0.95	0.341	1.34e-08	530.5085
Pseudo R2	0.3141					

Source: Field Survey 2022

The results showed that the possibility of artisanal fishermen micro-credit access decreases by 1.6% [(.984-1)*100] as interest rate increases holding other variables constant. The results also showed that the possibility of micro-credit access increases by 78% [(1.780-1)*100] and 15.5% [(1.155-1)*100] due to ownership of bank account and membership of cooperative respectively while controlling for other variables. Similarly, the likelihood of micro-credit access also increases by 114.6% [(2.146-1)*100] and 95.1% [(1.951-1)*100] as a result of increase collateral requirements and availability of loan guarantor while holding other factors constant. Again, as age and educational qualification increases there was possibility of micro-credit access by 24.97% [(1.2497-1)*100] and 36.1% [(1.361-1)*100] respectively. On the other hand, it was found that years of farming experience, ownership of fishing boat and type of occupation decreased the likelihood of access to micro-credit by 50.1% [(.499-1)*100], 38% [(.620-1)*100] 26.3% [(.737-1)*100] respectively.The Pseudo R^2 (0.3141) showed that the explanatory variables jointly explained 31.41% of the total variation in micro-credit access. This finding provides appreciable evidence for the reliability of the estimated logistic model.

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The study concludes that interest rate charged, years of farming experience, boat ownership and occupation type deceased the probability of micro-credit access. Based on the findings, it is concluded that collateral requirements and availability of loan guarantor were the major determinants of micro-credit among artisanal farmers.

5.2 RECOMMENDATIONS

1 That Government should ensure that banks and other micro-lending agencies do not impose difficult collateral conditions on micro-credits to enable artisanal fishermen increase their funding for higher productivity.

2. The study recommended that artisanal fishermen should open bank account and frequently do bank transaction since the study showed that ownership of bank account increases access to micro credit.

3 Government should ensure the formation of cooperative since cooperative membership increases access to micro credit.

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Engendering Technology Transfer and Usage in Agriculture among Gender: Implications for Self-Reliance in Food Production in Nigeria

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ABSTRACT

Gender responsiveness in agricultural technology is germane to food needs of future populations and it will ensure that agricultural productivity translates into improved welfare for the poor. Using gender friendly technologies for agricultural based activities will not only lead to food production but it will also ensure that women are recognized as key stakeholders in agricultural value chain not only in Nigeria but also in Africa. This will bring about efficiency and development that can benefit everyone in the society. It is worthy of note that successful development interventions are by their nature transformative because they create opportunities. Creating a gender inclusive agricultural technology is such a transformative intervention. By critically analyzing and understanding constraints facing women in agriculture, it will be possible to develop the new ways to addressing their needs and thinking of a way of enhancing their contributions in order to improve agricultural productivity with the aim of reducing hunger and alleviating poverty. This paper review how gender responsive technology in agriculture could help to tackle the incessant food shortage which women are mostly at the receiving end in Nigeria and describe some gender issues that influence technology usage. It was observed that women are not usually given adequate attention in technology development and transfer as they are seen as farmers' wives and not as farmers. Thus, the reason behind food shortage in Nigeria.

Keywords: gender, technology transfer, engender, self-reliance.

INTRODUCTION

A strong and efficient agricultural sector will enable a country to be food secured, creates foreign earnings, generate employment and above all supply raw materials for the various agricultural based industries in such countries. Agricultural sector has the potential to be the industrial hub of any country, especially in Nigeria where it was once served as the mainstay of the economy, generating as high as over and above 60% to the total Gross Domestic product (GDP) (Oji-Okoro, 2011). At this time, food insecurity was never a problem as every household was food secured and Nigeria as a country was industrial and economic springboard for other countries in Europe as many of their companies were situated in Nigeria due to the availability of raw materials obtained basically from the country's agricultural sector. Shortly, after 1960s and specifically, in the 1970s during the oil boom, gradual decline in agricultural sector sets in. Ukeji (2003) submitted that in the 1960s agriculture contributed up to 64% to the total GDP but gradually declined in the 70s to 48% and it continues in 1980 to 20% and 19% in 1985 ad this was largely attributed to oil glut of the 1980s.

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The significance of the high contributions of agriculture to the GDP of Nigeria was evidenced in her position being the world's largest exporter of groundnut, the second largest exporter of cocoa and palm produce and an important exporter of rubber, cotton in the 1960s (Sekunmade, 2009). More recently, agriculture employs about two-thirds of Nigeria's labour force, contributes significantly to the total GDP and provides a large proportion of non-oil earnings (Anyanwu, Ibekwe and Adesope (2010). Despite the decline in the GDP contribution, the sector has several untapped potentials for growth and development. This is manifested in the availability of natural resources like land, water and fertile soil and human factors like labour as well as the economic factor like large internal markets (Sekunmade, 2009). It is estimated that Nigeria has about 84 million hectares of cultivable land mass but as at 2011, only about 40% of this was under cultivation (FMARD, 2012). Productivity in the cultivated lands is also low due to small farm holdings capacity and crude methods farming as lack of technology advancement in Nigerian agriculture is one of the reasons for food shortage (Olatunji, 2002).

Owning to the food shortage experienced, Nigeria has therefore become heavily dependent on food imports. In addition to diverse and rich vegetation that can support crop cultivation and heavy livestock population, it also has potential for irrigation with a surface and underground water of about 267.7 billion cubic meters and 57.9 billion cubic meters respectively (Chauvin, Mulangu and Porto, 2012; Lipton 2012). Nigeria's large and growing population provides a potential for a vibrant internal market for increased agricultural productivity. These enormous agricultural related resources have the capacity to enable a country feed its growing population, earn foreign exchange, generate employment and provide raw materials for industries. Ordinarily, at both micro and macro levels, the agricultural sector is strategically positioned to have a high multiplier effect on the Nigeria's quest for socio- economic and industrial development. However, inability to use technology for farm operations and put gender at the center of technology development may be responsible for the current status of Nigeria in terms of food production. This paper critically looks at the trends in technology utilization in agriculture in Nigeria, reviews literature on gender inclusiveness in the development of technology for farm operations and describe gender issues in the usage of agricultural technology.

METHODOLOGY

The study is based on review of literature that were relevant to the main title. Therefore, **s**econdary data from literature were used for this documentation.

RESULTS

Food Production in Nigeria and Trends in Technology Usage

Sub-Saharan Africa is adjudged the poorest region in the world (Chauvin, Mulangu and Porto, (2012). Average real per capita income in 2010 was $688 compared to $1,717 in the rest of the developing world. Over the past 30 years, GDP growth per capita in SSA has averaged 0.16 percent per year. This failure of growth over the long term has resulted in high levels of poverty in the region. One finds the same picture of stagnation when one looks at the structures of African economies. In almost all of them production is dominated by the primary sector, mostly agriculture. This sector is marked by low productivity with little application of science and technology (Dercon and Beyrouty, 2009).

In Nigeria, the low application of technology in the agricultural sector has made foreign trade to mirror the production structure and exports dominated by primary commodities incorporating little application of science and technology while the bulk of manufactures and knowledge-based services are imported (Olajide, Akinlabi and Tijani (2012). Although, for the majority of African countries, the agricultural sector still provides a relatively large share of GDP but productivity in the sector has lagged considerably behind that of other continents and the potential that Africa can reach in the sector. While on average agriculture employs 65 percent of Africa's labor force it accounts for about 32 percent of gross domestic product, reflecting the relatively low productivity in the sector (Olajide*et al.*, 2012). For Africa therefore, the rural population has been unable to move out of poverty principally because they have not been able to transform their basic economic activity which is agriculture through technological utilization which is basic to the development of agriculture. Adopting and utilizing technology is not even enough but gender consideration in the technology development is a prerequisite to the development of agriculture. This is because women constitute significant proportions among the stakeholders in agricultural sector (Bilkisu and Ibrahim, 2016). In addition, owing to the importance of agricultural sector to the livelihoods of the poor, the World Bank in her 2008 World Development Report, devoted to Agriculture and Rural Development, that the sector must be placed at the center of the development agenda if the Millennium Development Goals of halving extreme poverty and hunger by 2015 are to be met. In view of this, appropriate technology that is gender inclusive and sustainable must be disseminated to farmers with a view to improving production.

Regrettably, the rate of hunger continues to increase after 2015 in Nigeria when the MDG target was to half hunger by 2015 in Sub-Saharan Africa. This connection between hunger and poverty was established by Janvry and Sadoulet (2002) and (Bilkisu and Ibrahim, 2016). The authors opined that efficient use of technology will lead to an improved in production and the implication is that the users will live above the poverty line of any country of the world. A technology becomes gender responsive when the needs of both sexes are considered in the usage (Deji, 2011) while its sustainability involves its usage over generations (Ogunsumi, 2010).

Karanyo (2002) affirmed that new technology in all areas of agriculture has improved production, hence, its sustainability. Today's Agriculture is using best management practices (BMP's), by targeting many of its applications, not broadcasting as was done in the past. New disease resistant hybrids, biological pest control, reduced pesticide use, cultural practices that reduce the incidence of pests and diseases, and better placement and reduced amounts of fertilizers are all being employed without any gender specific approach. Insect specific chemicals and biological insect controls are now being utilized, instead of broad-spectrum pesticides that actually reduce the number of sprays needed along with costs (Munyi, 2000). Nigerian agriculture needs to adopt specific gender approach to the above identified technologies for sustainability due to the contribution of women in food production. This will promote our reliance on safe domestic supply of food rather than relying on foreign imports which could affect our security if cut off and not be able to guarantee its safety in terms of the types and nature of technologies used in producing the foreign foods. Technologies have been developed by different research institutions and universities to improve the lots of farmers in Nigeria (Degrande and Duguma, 2000). These technologies are usually transferred through the ADPs to the target farmers and the extension agents are responsible for disseminating them using appropriate techniques for farmers to adopt. The extension agents also have a specific role of getting a feedback from the clientele to the origin of the technologies (with a view to improving on the weakness if there is any.

The Need for Gender inclusiveness in Technology Development and dissemination in Agriculture

Agriculture plays a significant role in poverty reduction in Africa. The high percent of people who engage in it may be used to explain this assertion. In rural area of Africa, Nigeria inclusive, agriculture employs over 75% of the population (IFAD, 2015), thus, it is an important livelihood source to many of these people in rural areas. It is estimated that 70% of sub-Saharan Africa's labour force works in agriculture (Maxwell, 2001). But the argument in favour of agriculture as *the* poverty alleviating sector *par excellence* rests on more than population statistics. Improvements in agriculturalproductivity have a powerful knock-on effect to the rest of the economy by: creating jobs in neighboring sectors such as food processing and input supply as well as directly in farming; increasing the supply of affordable food; and stimulating and supporting wider economic growth and development. However, women constitute the bulk of labour force in agricultural sector and they must be the target of any technology in agricultural production.

Generally, technology usage raises agricultural productivity and it is the major factor in creating positive effects which agriculture has on the economy of any nation. Thirtle, Lin and Jennifer (2003) explored the relationship between agricultural productivity and poverty in developing countries and established that a 1% improvement in crop yields reduced the proportion of people living on less than US$1 per day by between 0.6 and 1.2%. therefore, no other sector has demonstrated such a comparably high impact on poverty. This is in-line with the report of Lipton (2001) who argues that no other sector than agriculture offers the same possibilities in job creation and poverty reduction among people. Indeed, the adoption of new technologies and subsequent increases in agricultural productivity in different parts of the world explain, in large part, the regional differences in the reduction of poverty over the last few decades. Nkamleu, Gokowski and Kaziangor (2003) submitted that technological change was the main cause of the differences in the productivity.

Technological change in agriculture began at least 10,000 years ago, when the first cultivators selected wild plants and experimented with different growing environments. From those early beginnings, the technical performance of agriculture in the great civilizations remained roughly equivalent for centuries until the middle of the nineteenth century, where, principally in Europe and North America, the introduction of new machinery and sources of power (Grigg, 1974), the rediscovery of Mendel's experiments leading to the development of scientific plant breeding, and the development of artificial fertilizers, resulted in rapid increase in agricultural productivity (Doss, 2001).

Gender issues in Agricultural Technology design and usage

Gender issues can be understood with adequate understanding of some gender concepts as described by Deji (2011). Some of these concepts that may enable us to understand gender issues are: sex, gender roles and sex roles. Thus, understanding of gender roles is premised on the sound knowledge of the following concepts as described below:

Sex

Sex refers to the biological differences between male and female. These differences are congenital, unchanging/permanent, universal and most of the time, they are physical. They are natural and biological features and attributes that an individual is born with, which distinguish males from females in the society. Sex is genetically determined. Only a very small proportions of the difference in roles as to men and women can be attributed to biological or physical differences based on sex. For example, pregnancy, childbirth and differences in body physiology can be attributed to sex-related characteristics. This takes us to differentiate between gender and sex.

Differences between gender and sex

Specific differences between gender and sex

Gender	**Sex**
Rooted in the society	Natural/biological
It can be influenced by culture	It cannot be influenced by culture
It varies from culture to culture	It does not vary from culture to culture
It can be changed	It cannot be changed/congenital
Gender may be biased	It cannot be biased
It is time specific	It is not time specific
It is learnt through socialization	It doesn‘t need socialization to learn sex

Source: National Open University Module, 2015.

Gender role

Roles are functions performed by individuals in the social positions they occupy. Gender roles are those functions that are culturally allotted to individuals on the basis of their gender but are not related to biological functions of that individual. They are roles that can be carried out by a man or a woman. The assigning of such roles varies from societies to societies and from culture to culture and over a period of time. Gender roles relates to what a man or a woman should do and how a person of a particular gender walks, talk, dresses and relates with outsiders (Deji, 2011). All these are culturally determined. For example, child caring is allotted to women. Its therefore becomes a female gender role but not a female sex role since a man or a woman can carry out the function. Also, household chores such as washing of plates, fetching of water among others are women's works in many societies but a man can equally perform these roles as well. However, sex roles like carrying a pregnancy or breast-feeding that are exclusively for female require some specialized organs. This is why such roles are exclusively for the females. Therefore, in gender roles, no specific organ is required for it to be performed. For example, a man needs his hands and his brain to work as a medical doctor. Also, a woman also needs the same thing to perform the same function. Therefore, both men and women can be medical doctors. Medical profession becomes what both men and women can do. It is not a sex role but rather a gender role. Hence, gender roles are also a set of expectations as to what ought to be the appropriate behaviour for men and women under particular circumstance.

Sex role

These are naturally endowed duties given to the women. These duties require certain biological characteristics in order to perform them. For example, a woman requires a womb to carry a pregnancy, a breast to breastfeed her baby and a man requires a specific and specialized organ to impregnate a woman. These are sex roles which a member of a given sex can perform (Deji, 2011). Sex roles are permanent as they cannot be changed by culture or society. A man cannot carry pregnancy because he has no womb to do so. However, child rearing is a gender role and not a sex role since both men and women can carry out these functions.

Gender Issues

Gender issues arise where an instance of gender inequality is identified. In most cases, it arises as a result of misinterpretation of gender roles and sex roles. This becomes manifest where there is discrimination and oppression against a particular sex leading to a gender gap or inequality among male and female. For example, the involvement of female children in household chores such as washing of plates, cooking of foods, fetching of water while the male children will be allowed to play football and read their books deny the female children from studying and subsequently, affects their performance in schools. This discrimination and oppression becomes a gender issue. This is applicable to the development of technologies for farm operations. Usually, technologies are developed for farmers and in Africa, whenever a farmer is mentioned, male picture comes to mind. This is the picture in which planning of programmes for farmers is usually based upon.

Therefore, gender-related effects of technology change are often important in determining the impact of adoption on poverty. Technology generation tends to favour even crops traditionally grown by men, who frequently have greater access to labour, markets, credit and other inputs than women to a degree that may impact negatively on the intra-household distribution of income and consumption (Doss, 2001). Addressing these challenges goes well beyond technology design, as male dominated societal rules and norms, and a complex household environment of 'joint decisions, multiple objectives and mutual dependence' (Bonnard and Scherr, 1994) make it difficult to target, or predict the gender-related outcomes of technology development. Simply targeting technology to women's crops is not necessarily the answer (Von Braun and Webb, 1989) but technology that meets the needs of both gender will probably provide a sustainable platform to meeting the food needs of Nigerians.

CONCLUSION

The focus of technology development will, at its most fundamental level, need to be guided by an understanding of the future direction of agriculture in Nigeria and an appreciation of the changing ways in which it will contribute to growth and poverty reduction. While the initial nomenclature of farmers as males has changed but the packages and programmes meant for them still remain unchanged. The men are still better favoured in access to technology and other productive assets than the women. The consequence of this unchanging approach to increasing food production may be responsible for the huge cost of importing food from other countries into Nigeria. Therefore, for Nigeria to be food reliance and sustained, gender must be put at the center of deliberations when technology is to be developed for farmers.

RECOMMENDATION

1. Technology developers must factor in gender considerations while developing farm-based technologies targeted at improving agricultural productivity in Nigeria
2. The usually nomenclature of farmers being men must change to include men and women when designing agricultural technologies for farmers.

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Sub-Theme B: Crop production, improvement strategies and seed technology, Forest resources, Ecotourism, Wildlife and environmental management issues and strategies and Soil and water resources conservation and management
(Cont'd)

Efficacy of diatomaceous earth (Protect-It) on management of Cowpea Beetle (*Callosobruchus maculatus* (Coleoptera: Chrysomelidae)) infesting stored Bambara groundnut (*Vigna subterranea*)

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ABSTRACT
Laboratory studies was conducted at Entomology Laboratory of University of Maiduguri under ambient laboratory conditions to assess the efficacy of diatomaceous earth (DE) against *C. maculatus* infesting bambara groundnut. The bioassays were conducted on treated seeds of Bambara groundnut variety *Farin ngangala*. *C. maculatus* adults was bioassayed on 50g seed samples using CRD replicated three (3) times at the following dose rates; DE (250, 500, 750, 1000, 1500 mg/kg of seeds) The effects of treatments on seed germination was conducted on freshly treated seeds and at 90 days after treatment (DAT). The results showed that DE applied at 1000mg/kg and 1500mg/kg completely suppressed ovipostion, adult emergence, damage and weight loss. DE only affected germination at the highest dose rate of 1500mg. It was concluded that DE could be used to manage *C. maculatus* populations in stored bambara groundnut.

Keyword: Diatomaceous earth; Cowpea; Oviposition; Mortality; Germination

INTRODUCTION

Bambara groundnut, (*Vigna subterranea* L. (Verdcourt)), is a leguminous crop of the order Fabales, family Fabaceae and sub family, Faboidea, with creeping stems and branching just above ground level. The seeds are variously colored from white to cream, red, black or brown, sometimes mottled; blotched or striped (Bamshaiye *et al*., 2011). The seeds are used in many types of foods, some of which are an important part of human diets. Mature, dry seeds are boiled and eaten as a pulse. Seeds can be milled to make flour. Ripe seeds are very hard and must be cooked for longer than those of other legumes. Like other legume plants, *V. subterranea* is a good soil fertilizer and a good rotation crop. It does not require any additional fertilizer. It is generally intercropped with cereals (maize, sorghum, and pearl millet), other pulses (cowpea, groundnut), root and tuber crops, or vegetables. Cream-coloured seeds are often preferred to red and black seeds, because they are less bitter and take less time to cook. Large seeds are preferred to smaller ones, especially for use as a snack. Smaller seeds are ground into flour for use in various recipes. The processing of *V. subterranea* results in by- products (shells of offals) that can be fed to animals. Seeds can also be fed to animals if surplus to human requirements. The leafy shoots are used as fodder (Brink *et al.*, 2006). The seeds are used for food and beverage because of their high protein content and for digestive system applications. The entire plant is known for soil improvement because of nitrogen fixation. According to Mazahib *et al*. (2013), high carbohydrate (65%) and relatively high protein (18%) content as well as sufficient quantities of fat (6.5%) make the Bambara groundnut a complete food. According to Bamashiye *et al*. (2011), Bambara groundnut seeds have been found to be richer than peanuts (groundnuts) in essential amino acids such as isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine. This is an important trait for the potential of bambara groundnut to be used to complement foods lacking in these essential amino acids. The fatty acid content is predominantly linoleic, palmitic and linolenic acids, (Minka and Bruneteau, 2000). The major bruchid species that infest bambara groundnut in storage are: *Callosobruchus maculatus* Fabricus, *C. subinnotatus* Pic, *C. chinensis* Linnaeus and *Zabrotes subfasciatus* Bohemian (Ayamdoo *et al.,* 2013). Of these, *C. maculatus* is the major storage pest of Bambara groundnut seeds (Ayamdoo *et al*., 2013; Magagula and Maina, 2012). They are field to store agricultural pests of Africa and Asia (Beck and Blumer, 2014) and are the most destructive on account of their shorter life cycle (Maina and Lale, 2004). The weevil can cause as much as 99% yield or weight loss in susceptible grain legumes.

The damage results in quantitative and qualitative losses. To combat these debilitating storage pests, farmers and traders in west Africa use storage structures and other available materials like earthenware pots, gourds, mud silos, jute sacks, bagco bags, metal drums, plastic containers and local granaries for grain storage. These are most often, integrated with synthetic pesticides (Aviara *et al*., 2013 and Ayamdoo *et al*., 2013). However, the unabated use of toxic synthetic chemicals has given rise to problems of toxicity, pest resurgence and elevation of secondary pests, development of pesticide resistant populations, deleterious effects on population of non–target organisms, residues in food chain, high costs of most of the chemicals, contamination of the environment, non–availability and the falsification and adulteration of pesticides (Bloch, 2012; Grzywacz and Leavett, 2012).

In this effect, the increased awareness and concern for biorational alternatives, which are effective, economically sound, feasible, and user friendly, have gained an important position in the protection of stored products. They are safe, effective, and relatively simple prevention and control methods available to manage populations of stored-product insect pests without the use of chemical insecticides. The use of biorational approach provides practical economical and safer ways to managing stored-product insect pests. These approaches are either directly take advantage of key aspects of the pest's biology to eliminate or manage pest populations through manipulation of the physical and biological environments of the target species. Control of stored-product insects by desiccation can be facilitated by treatment of infested commodity and spaces with diatomaceous earth (DE). DE represents the fossilized silicon dioxide skeletons of diatoms, which are unicellular aquatic algae. DE kills insects following contact exposure by absorbing the hydrocarbons from their cuticles, which causes dehydration and ultimate death (Korunic, 1998). The activity of DE is increased under low humidity and higher temperatures. An enhanced DE was developed that utilizes added silica gel, a finer and more homogenous source of silicon dioxide (Korunic and Fields, 1998). DE is nontoxic to vertebrates and is even a common food additive and food-processing agent with the designation GRAS (generally regarded as safe). The efficacy of DE varies significantly among its geographic source locations where it is mined, so users must follow label instructions closely to ensure control (Korunic, 1998). Application of DE at effective rates to an entire grain mass can cause a significant loss in bulk density, thus lowering the quality and value of the treated grain (Korunic *et al*., 1996); care should be taken to use minimal effective rates or to treat problem areas only (e.g., the top or bottom layers of the grain mass). The objective study was to evaluate the efficacy of Diatomaceous earth on management of *Callosobruchus maculatus* infesting stored Bambara groundnut.

Materials and method

Study Site

The study was conducted at the Entomology Laboratory of the Department of Crop Protection, Faculty of Agriculture, University of Maiduguri. All experiments were conducted under ambient laboratory conditions. Temperature and relative humidity ranged from 28 to 34°C and 22 to 58% respectively. The study was conducted during the period of March – June.

Source of the Insects

Cowpea Bruchid; *Callosobruchus maculatus* adults were collected from cultures maintained on cowpea in the laboratory and was used to establish new cultures on Bamabara groundnut. The insects were then reared for two generations on Bambara groundnut for the experiments. Culturing entailed placing a hundred unsexed adult insects onto 300 g of sterilized Bambara groundnuts seeds placed in 1-liter capacity jar for seven days and then sieved out and discarded. The resulting F_1 generation aged 1 – 2 days old were used for the experiments.

Handling of Bambara Groundnut Seeds

The seeds, after acquisition, were cleaned and placed in deep freeze refrigerator for 2 weeks to kill all life stages of the insect that might be present. The seeds were conditioned to room temperature for at least ten (10) days before commencement of the experiment.

Source of diatomaceous earth (DE)

Diatomaceous Earth was provided by the Department of Crop Protection, University of Maiduguri, from samples obtained from Diatom Research Consulting Incorporation, Canada.

Bioassay Procedures for Determination of Efficacy of Diatomaceous Earth against *C. maculatus.*

The bioassays were conducted on treated seeds of the variety *Farin ngangala*. The choice of application rates were based on published literature, largely on studies arising from control of pest infesting stored cowpea. The application rates used in the present study were: D.E (250, 500, 750, 1000, 1500 mg/kg of seeds)

Grain treatment, bioassay and experimental design

Fifty grams of *Farin ngangala* cultivar seeds were placed in a 150 ml jar and the appropriate treatments were applied on the seeds. The jars were shaken vigorously to ensure proper mixing after which they were infested with newly emerged (1 – 24 h old) adult bruchids from the culture. Five pairs of the newly emerged adult *C. maculatus* were introduced per jar. The jars were covered and then arranged on the laboratory bench using CRD. Each treatment combination (insecticidal material x dose) was replicated three (3) times. The adults were allowed to oviposit for seven (7) days after which they were sieved out and discarded.

Observation and data collection

Egg counts were carried out seven (7) days post treatment. This was done by random draw of 20 seeds from each jar in each concentration per treatment. The seeds were observed with a magnifying glass (x 100) and the number of eggs on the seeds was counted. The number of adults produced in each jar was counted forty (40) days after infestation. The percentage damage and percentage weight loss was determined by randomly taking 50 seeds from each jar, and then separated into holed (damaged) and whole (undamaged) grains. The seeds in each category were counted and the numbers used to calculate the percentage damage:

$$\text{Percentage seed damage (SD) (\%)} = \frac{\text{Number of damaged grains}}{\text{Total number of grains}} \times 100$$

For percentage weight loss, the grains in each of the above categories were weighed, and the weights used to calculate the percentage weight loss according to Golob *et al*. (1982).

$$\text{Weight loss (\%)} = \frac{(Und) - (Dnu)}{U\,(nd + nu)} \times 100$$

Adult emergence inhibition rate

Adult emergence inhibition rate (AEIR) was calculated according to Kabir (2011) as:

$$AEIR\% = \frac{Ne - Na}{Ne} \times 100$$

Hatching rate

$$\text{Hatching rate was calculated as: } \frac{\text{Number of emerged } F_1 \text{ progeny}}{\text{Number of eggs produced}} \times 100$$

Determination of Treatment Effect on Seed Germination

Germination test was conducted according to the methods described by the International Seed Testing Association, 2015. Two germination tests were conducted. The first was carried out at the beginning of the experiment with freshly treated seeds. Whereas the second test was performed on treated seeds described earlier and infested with the insects ninety (90) days after treatment (DAT). From each treatment combination (insecticidal material x dose), ten (10) seeds were selected randomly from each jar and placed on moistened plastic Petri dishes, lined with Whatman's No. 1 filter paper. The petri dishes were labeled and arranged on a laboratory bench using CRD for seven days. There were four replicates per treatment combination. Germinated seedlings were counted after seven (7) days. And percentage germination was calculated using the formula.

$$\text{Germination percentage} = \left[\frac{\text{Number of seed germinated}}{\text{Total number of seeds in each petri dish}}\right] \times 100$$

Data Analysis

The data were subjected to analysis of variance (ANOVA) using statistical software (Statistic 8.0). Differences in mean values of treatment were separated using Tukey Kramer's honestly significant difference (HSD) at 5% level of probability. Data on germination test were subjected to T- test to determine any differences between the freshly treated seeds and those treated and stored for 90 days.

Table 1: Effect of diatomaceous earth on ovipostion, adult emergence, hatching rate and inhibition rate of *Callosobruchus maculatus* on Bambara groundnut seeds

Application rate (mg/kg)	Oviposition	Adult Emergence	Hatching rate (%)	Inhibition rate (%)
0.0	193.7 ± 9.8[a]	144.3±4.7[a]	74.7±1.8[a]	-
250	33.7 ±2.3[b]	13.7± 4.1[b]	39.4± 9.9[b]	90.5
500	22.7 ± 4.3[bc]	7.7 ±2.7[bc]	32.0± 5.7[b]	94.7
750	11.0 ±4.6[bc]	2.0±0.6[bc]	20.0± 2.9[bc]	98.6
1000	2.0 ±1.0[c]	0.0± 0.0[c]	0.0 ± 0.0[c]	100
1500	0.0 ±0.0[c]	0.0± 0.0[c]	0.0 ± 0.0[c]	100
F	235	422	33.5	-
P	<0.0001	<0.0001	<0.0001	-

*Means within a column followed by same letters are not significantly different from one another (Tukey Kramer's HSD test)

Effect of diatomaceous earth against *C. maculatus* and seed germination of Bambara groundnut.

The effect of diatomaceous earth on ovipostion, adult emergence hatching rate and inhibition rate of *C. maculatus* on stored Bambara nut at different dose rates is shown on Table 1. Compared to control, there was a drastic decrease in the number of eggs even at the lowest dose rate 250g. Oviposition further decreased with increase in dose rate as low as 0.0 in the highest dose. The result shows that there was significant difference P=<0.0001 between dose rates and control. Treatment also showed significant effect P=<0.0001 on adult emergence. Adult emergence reduces with increase in dose rate up to 0.0 at dose rate 1000 g and 1500 g. The results on hatching rate and progeny inhibition showed significant difference between dose rate and control, there was 0.0 % hatching rate and 100% inhibition rate at dose rates 1000g and 1500g due to 0% adult emergence. Dose rates varied significantly with the control, hatching rate decreased with increase in dose rare while inhibition rate increased with increase in dose rate.

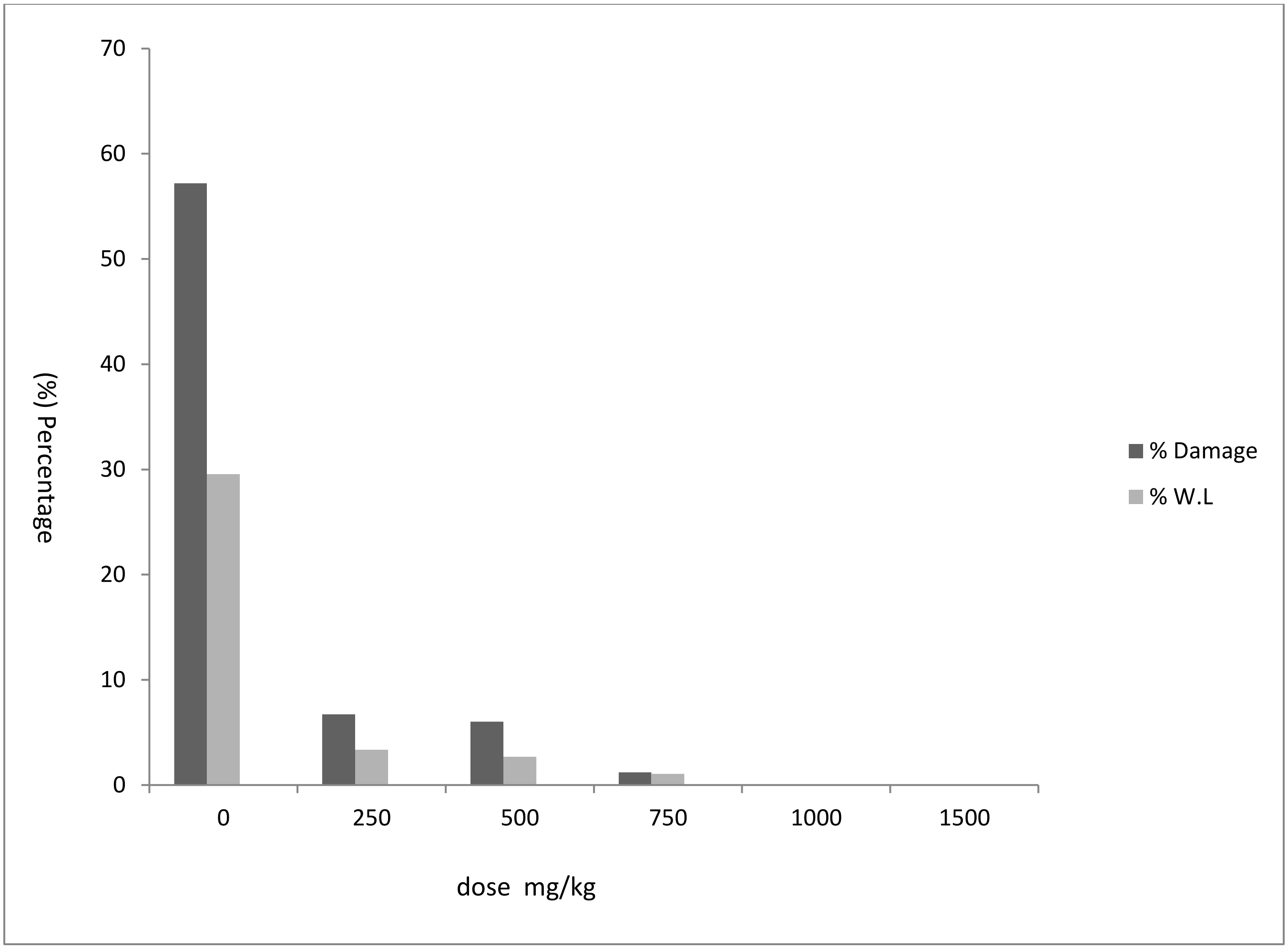

FIG 1: EFFECT OF DE ON PERCENTAGE DAMAGE AND WEIGHT LOSS OF STORED BAMBARA GROUNDNUT CAUSED BY *CALLOSOBRUCHUS MACULATUS*

Effect of diatomaceous earth against *C. maculatus* on percentage seed damage and weight loss of Bambara groundnut.

Percentage damage and weight loss decreased with an increasing dose rate (Fig 1), with decrease of 0% at dose rates 1000 and 1500mg/100g.

Table 2: Effect of diatomaceous earth on seed germination of bambara groundnut

Application rate (ml/kg)	% germination 0 days after treatment	% germination 90 days after treatment	T-test
0.0	100.00a	100.00a	Nd

250	100.00a	100.00a	Nd
500	100.00a	100.00a	Nd
750	95.00ab	100.00a	0.0917
1000	92.50bc	98.75a	0.0154
1500	88.75c	93.75b	0.0917
F	17.5	12.0	-
P	<0.0001	<0.0001	-

*Means within a column followed by same letters are not significantly different from one another (Tukey Kramer's HSD test)
Nd – not determinable

Effect of diatomaceous earth on seed germination of Bambara groundnut

The effect of diatomaceous earth on Germination rate of Bambara groundnut at 0 DAT showed that treatment did not differ with control at 250, 500 and 750g; 750g and 1000g did not vary; and 1000g and 1500g do not vary with each other. At 90 DAT dose rates did not vary with each other except the highest dose. T-test showed no significant difference P=<0.0001 between germination at 0 DAT and 90 DAT at dose rate 0.0, 250mg and 500mg (Table 2).

DISCUSSION

The findings from this study indicated that Protect-It can be used successfully as a protectant against adults of Cowpea bruchid *Callosobruchus maculatus*. Regardless of the synergism of other factors, the effect of DEs is dose-dependent (Fields & Korunic, 2000; Athanassiou *et al*., 2003; Stathers *et al*., 2004; Mahdi & Khalequzzaman, 2006), as in the case of residual insecticides used as grain protectants. The overall efficacy depends upon different factors such as type and concentration of DE, grain moisture content, temperature, insect species, insect density and type of grain commodity (Korunic and Fields, 2006). Among these factors, temperature and relative humidity plays an important role in determining the efficacy of DE against stored insect pest (White and Loschiavo, 1989). However, the dose rate is more important in the case of inert dusts, given that the presence of dust in seed highly affects the physical properties of seed (Korunic *et al.*, 1996). In addition, dust formulations that are effective at high application rates (Subramanyam & Roesli, 2000). In the present study, the rates of 1500mg/kg produced high mortality levels, 100% was achieved in most of the cases examined. However, given that *C. maculatus* cannot survive at application rates higher than 1000mg/kg and are effective against other stored-grain beetle species (Fields & Korunic, 2000), higher dose rates or longer exposure intervals are needed to achieve 100% mortality for adults of this species. Moreover, this insecticide has a long persistence after treatment (Kabir and Lawan, 2016). Fields and Korunic (2000) have confirmed the effectiveness of several DE-based formulations on adults of *Tribolium castaneum*. As proven in this work, *C. maculatus* express susceptibility to DE due to morphological, physiological and ecological characteristics.

The efficacy of diatomaceous earth on the mortality of insect pests of stored products is usually affected by several factors among which stands out the temperature (Chanbang *et al*., 2007). Generally, the increase in temperature favors the increase in the effectiveness of this product by stimulating the movement of insects within the grain mass, providing an increased contact of them, with the diatomaceous earth (Vayias *et al*., 2009). In addition, the insects have higher respiration rates at higher temperatures and consequently the greater water loss via spiracles promoting desiccation (Zachariassen, 1991). However, it was shown in some studies that the insect mortality can vary between species (Vayias *et al*., 2009).

Increased exposure time is highly important for DE efficacy, since surviving individuals may disperse from the treated substrate and colonize untreated parts of the product mass (Subramanyam and Roesli, 2000). This fact must be seriously taken into account in cases of partially treated grain masses with DE, such as the surface treatment in grain bulks, when DE in the surface is used alone, as a barrier to infestation (Korunic and Mackay, 2000). Earlier studies have shown that stored grain insect pests can be controlled by commercially available DE formulations. For example, Kavallieratos *et al*. (2005) used DEs Insecto and SilicoSec on eight different grain commodities, at 750 mg/kg and recorded mortality after 14 days of exposure ranging from 63 to 97%. Similarly, Vardeman *et al*. (2006) reported that Protect-It at the same exposure found that 400 mg/kg gave 85% adult mortality for *R. dominica*. However, our findings are consistent with the results reported in other studies (Fields and Korunic, 2000; Athanassiou and Kavallieratos, 2005). Athanassiou *et al*. (2006) reported 100% mortality of the exposed *R. dominica* adults after 14 days in wheat. However, longer exposure interval suppresses the progeny emergence in the treated substrate provided the dry condition prevails (Athanassiou *et al.*, 2005). Also, Paula (2001) reported that the higher dose rate was negatively correlated with the production of F_1 of *Sitophilus* spp. The present trial undoubtedly supports the statements of other researchers as there was less progeny at high dose rates and longer exposure intervals, which practically prevented damage and weight loss.

CONCLUSION

Conclusively, DE proved to be effective in managing *C. maculatus* on stored bambara groundnut. The treatments significantly reduced oviposition and progeny emergence, which varies significantly with control. Similarly, treatments decreased damage and weight loss significantly compared to the untreated control. Treatments increased effectiveness with increase in dose rate. All treatments did not significantly reduce germination both at 0 DAT and at 90 DAT except in control treatment.

RECOMMENDATIONS

It is recommended that DEs should be adopted by farmers as alternative for synthetic insecticides, as they have proven effectiveness in the management of *C. maculatus* on stored Bambara nut. DE could be used at 1000 mg/kg. The use of DE as a safe control method against stored pests is highly recommended. The results obtained indicate the potential of non-chemical method development.

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Agronomic Performance Of Some Sugarcane Hybrid Clones At Badeggi, Nigeria

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ABSTRACT

The need for indigenous developed sugarcane varieties cannot be over emphasized as the sugar estates in Nigeria depends more on exotic cultivars that succumb to pests/diseases and suffer quick yield decline due to non-adaptability in their new environment. Sugarcane production is very important in the country, as its plays a vital role in food and income security. A study was conducted to evaluate the performance of sixteen sugarcane hybrid clones at NCRI Badeggi. The clones were planted on Randomized Complete Block Design (RCBD) with three replications. Analysis of variance reveals significant differences among the clones for some traits. Highest cane yield (175.7 tha^{-1}) was recorded in BD 1098-003m. BD1098-001m clone gave the best brix (21.4%) and sugar yield (17.47 tha^{-1}) among the studied hybrids. BD 1098-005m, BD 441-007m and B 47419 possess better fibre and such materials can be manipulated for energy cane variety.
Brix percent also varied among the clones with increase in crop age, which can be used as indicator for maturity. This evaluation has revealed the performance of some hybrid clones and they will be nominated for further evaluations (yield trials).

INTRODUCTION

Sugarcane is one of the most important commercial and cash crop cultivated for sugar production across the world. It contributes about 75% of the world sugar production, while sugar beet produces 25% (Mani *et al*., 2019). It is grown in Nigeria on small scale for home uses and on large industrial scale for refined sugar production and it's by products (Takin *et al*., 2019). Sugarcane production is vital for Nigeria economy diversification as huge resources is invested in sugar importation annually. Its production in Nigeria is profitable with a return of ₦1.88 for every naira invested as documented by Aina *et al*., (2015). Africa contributes only 5% to the current global sugarcane production and 83% of this is in Sub-Saharan Africa. The Sub-Saharan African region, with its tropical and subtropical climate, is well-suited in many ways to expanding the production of sugarcane.

Nigeria annual raw sugar production averages is 80,000 metric ton despite annual consumption of 1.7 million metric ton. According to Nigeria Sugar Annual (2019), the country imports about 1.6 million metric ton of raw sugar from Brazil, Thailand and the United States to meet its demand.

Ishaq *et al*., (2019) has highlighted lack of improved high yielding and adaptable sugarcane varieties as major setback for sugar production in the region. Olaoye (1999) has sighted the need for locally improved sugarcane varieties which will also be adapted to our ecology as part of constrains to sugar production in the country. The goal of sugarcane (*Saccharum species*) breeding is to develop genetically improved varieties with high sugar yield (cane yield and sucrose content) that will be economically sustained over several ratoon crops. Sugarcane yield can be improved in Nigeria through, hybridization, evaluation and adoption of promising clones to the country ecology. Increased cane yield is a function of higher genetic potential of the clones (Nazir *et al*., 1994) and can only be reveal through a progeny performance evaluation. The remedy for less cane yield and sugar recovery problem relies on cultivation of improved cane varieties (Chattha *et al*., 2006). Sugarcane cultivars varies in juice quality characteristics, cane yield, maturity, flowering and and yield per hectare arising from inter-species hybridization involving four species (S. *officinarum*, S. *barberi*, S. *sinense* and S. *spontaneum*) of the genus Saccharum (Moore *et al.*, 2014).

Performance of various clones and their agronomic traits studies are paramount before a variety is accepted for commercial cultivation (Maqbool *et al*., 2001).

Therefore this study was conducted to evaluate and revealed the performance of some sugarcane hybrid clones at National Cereals Research Institute, Badeggi Nigeria.

MATERIALS AND METHODS

This study was carried out by sugarcane research program of the National Cereals research Institute, Badeggi, Niger State, Nigeria (NCRI). Fourteen promising clones (obtained from fuzz raising) were advance from progeny testing II series to preliminary yield trial. The fourteen clones with two commercial varieties (B 47419 and N 27) were planted in a randomized complete block design (RCBD). Each clone was planted on a 5 m x 5 m plot and replicated three times. Sixty cane setts (three budded) were planted per plot. The Preliminary Yield Trial was established 09th October, 2018 and all cultural practices for sugarcane production were adopted according to recommendations of NCRI Badeggi. Juice analysis was carried out at the NCRI laboratory for qualitative traits.

Table 1: List of Sugarcane Hybrid Clone and their Parentage

Genotypes	**Parents (Female X Male)**	**Status**
BD 140-02m	M 1551/80 X F77790	Progeny of Mauritius fuzz
BD 140-011m	M 1551/80 X F77790	Progeny of Mauritius fuzz
BD 140-014m	M 1551/80 X F77790	Progeny of Mauritius fuzz
BD 1098-001m	M 2256/88 X POLYCROSS	Progeny of Mauritius fuzz
BD 1098-003m	M 2256/88 X POLYCROSS	Progeny of Mauritius fuzz
BD 1098-005m	M 2256/88 X POLYCROSS	Progeny of Mauritius fuzz
BD 1098-014m	M 2256/88 X POLYCROSS	Progeny of Mauritius fuzz
BD 441-004m	M 1489/91 X POLYCROSS	Progeny of Mauritius fuzz
BD 441-007m	M 1489/91 X POLYCROSS	Progeny of Mauritius fuzz
BD 575-007m	M 422/91 X R570	Progeny of Mauritius fuzz
BD 1354-20m	M1672/90 X R570	Progeny of Mauritius fuzz
BD 1576-31m	M2256/88 X R570	Progeny of Mauritius fuzz
BD 1576-07m	M2256/88 X R570	Progeny of Mauritius fuzz
BD 1576-14m	M2256/88 X R570	Progeny of Mauritius fuzz
N 27		Commercial Variety
B 47419		Commercial Variety

Data was collected on germination and establishment (%) at 21 and 42 days after planting respectively, tiller count at 3 months after planting, stalk girth, plant height at 6 month, stool per plot, stalk per plot, milleable cane per plot and cane yield ton/ha at maturity. Brix (sugar content) was measured with the aid of refractometer at 8th, 9th, 10th and 12th months after planting.

Recoverable Sucrose percent (RS)

$$\text{RS (\%)} = \left[\text{Pol \%} - \frac{(\text{Brix} - \text{pol})}{2} \right] \times \text{JF.}$$

Juice Factor = 0.65

$$\text{Sugar Yield (t/ha)} = \frac{\text{Cane Yield tha}^{-1} \times \text{Recovery Sucrose}}{100}$$

(Islam *et al*., 2011).

RESULTS AND DISCUSSION

Result from the table below significantly reveals differences among the hybrid clones for some growth traits. BD 140-014m has higher germination than other clones except BD 1098-014m. The result on germination percent is in conformity with the report of Mohammed *et al*., 2019. According to the table below, 1098-014m has more established plants (68.3) than some studied clones (BD 1098-001m, BD1098-005m, BD441-004m, BD 575-007m, BD 1354-20m, BD 1576-31m, BD 1576-07m and BD 1576-14m) and lowest establishment was recorded in BD 1576-31m. BD 1098-014m has the highest number tillers which was significantly superior to the number of tillers recorded for all the studied clones.

Table 2: Mean values for growth performance of selected hybrid sugarcane genotypes evaluated at NCRI Badeggi (2018/2019)

GENOTYPE	SPROUT	TILLER	ESTAB	PLH 6
BD 140-02m	52.7	70.7	62.7	161.9
BD 140-011m	39.7	70.0	57.0	196.1
BD 140-014m	64.0	106.3	62.7	223.3
BD 1098-001m	37.0	59.0	51.0	188.5
BD 1098-003m	46.0	100.3	59.7	204.5
BD 1098-005m	43.0	26.7	44.0	145.9
BD 1098-014m	58.0	161.7	68.3	165.6
BD 441-004m	41.7	71.3	40.0	186.3
BD 441-007m	54.0	127.0	66.3	158.9
BD 575-007m	19.0	73.3	47.7	151.0
BD 1354-20m	18.0	59.0	26.0	162.3
BD 1576-31m	12.3	27.3	22.0	157.6
BD 1576-07m	20.3	82.3	39.7	159.8
BD 1576-14m	23.7	86.7	46.0	206.1
N27	50.0	100.0	62.0	212.7
B47419 (check)	46.3	78.3	62.7	202.9
	**	**	**	**
SE±	3.0	6.0	4.7	8.3
CV%	13.3	12.8	16.1	7.9

Means were separated using SE± at P<5%.
Note: sprout (%), Tiller= number of tillers per plot, Estab= establishment count, PLH 6= plant height at six months after planting

There was no significant different recorded among the studied sugarcane hybrids clones for number of stalk per stool (Table 3). However BD 1098-014m has more number of milleable stalks (140.6) per plot and 1576-07 BD has the lowest milleable cane per plot. Maximum stalk girth (2.8 cm) was recorded for BD 140-014m and BD 1098-005m, which compare significantly better than the girth of B47419 (commercial check). The variation noted in the stalk girth was in conformity with the result of Soomro *et al*., (2006), that documented differences among twelve promising sugarcane varieties in Thatta, Pakistan. The highest cane yield (186.5 t/ha) was recorded in BD 1098-003m which was significantly the same with the yield recorded for N 27 and the lowest yield was noted in BD 441-004m. Khan *et al*., (2004) had also reported higher cane yield of 174.4 t/ha. Higher cane yield exhibited by some studied clones might have been inherent genetic potential of the progenies and higher cane yield is also known to be the function of higher genetic potential of a variety as documented by Nazir et *al.* (1997). Variability among the clones for yield per hectare is in agreement with report of other researchers (Getaneh et al., 2015, Ali et al., 2017 and Islam et al., 2011)

Table 3: Mean values for yield performance of selected hybrid sugarcane genotypes evaluated at NCRI Badeggi (2018/2019)

GENOTYPE	STK/STUL	MIL/PLT	STL/PLOT	GIRTH (cm)	YIELD (ton/ha)
BD 140-02m	4.7	111.7	23.7	2.1	107.3

BD 140-011m	7.9	113.3	16.0	2.3	122.0
BD 140-014m	5.0	89.0	26.0	2.8	114.3
BD 1098-001m	6.1	130.3	17.3	2.2	164.0
BD 1098-003m	5.9	106.0	17.7	2.0	175.7
BD 1098-005m	6.2	70.3	10.3	2.8	91.0
BD 1098-014m	7.4	140.3	19.3	2.0	160.3
BD 441-004m	6.8	122.0	16.0	2.0	76.0
BD 441-007m	6.0	103.3	16.3	2.0	104.0
BD 575-007m	6.7	94.7	16.3	2.2	105.0
BD 1354-20m	7.6	77.0	21.3	2.4	124.7
BD 1576-31m	7.3	73.0	19.3	2.2	96.7
BD 1576-07m	7.0	67.3	15.7	2.4	97.7
BD 1576-14m	4.7	120.7	18.3	2.1	106.7
N27	6.9	130.7	18.3	2.4	169.0
B47419 (check)	5.1	131.0	15.7	1.9	97.3
	NS	**	**	**	**
SE$\pm$	0.8	4.7	1.6	0.2	6.52
CV%	21.0	7.7	15.1	12.1	9.5

Means were separated using SE$\pm$ at P<5%.
Note: STK/STUL= stalk per stool, MIL/PLT= milleable stalk per plot, STL/PLOT=stool per plot

The result on table 4 shows significant different among the studied clones for Brix percentage at 10 and 12 months after planting. BD 1098-001m and 1576-31 BD gave the best Brix (21.4% and 21.1%) and the lowest brix was noted in BD 441-007m. In some studied clones (BD 140-02m, BD 140-011m, BD 1098-001m, BD 1098-003m, BD 1098-005m, BD 1098-014m, BD 441-004m, BD 575-007m, BD 1576-31m, BD 1576-07m, BD 1576-14m, B 47419) the brix percent tend to increase as the age of the crops increases. Most of the studied genotypes exhibit higher brix percent than the check (B47419) nd is in conformity with the result of Ali *et al*., 2020 that studied the performance and stability analysis of some sugarcane genotypes across different environments in Egypt. It has also been suggessted that brix accumulation of genotypes depends on crop-age and environment (Mebrahtom *et al*., 2017).The time of highest Brix percent of a sugarcane clone can serve as an indicator for crop maturity in non-flowering condition.

Table 4: Trend of sucrose (brix) accumulation for hybrid sugarcane genotypes evaluated at NCRI Badeggi (2018/2019)

GENOTYPE	BRIX 8	BRIX 9	BRIX 10	BRIX 12
BD 140-02m	15.3	16.4	18.4	20.3
BD 140-011m	15.1	15.7	15.6	17.5
BD 140-014m	14.5	18.0	17.0	18.0
BD 1098-001m	17.1	18.1	20.7	21.4
BD 1098-003m	17.9	18.3	18.1	18.9
BD 1098-005m	14.3	16.7	18.4	20.6
BD 1098-014m	16.5	16.8	19.0	19.4
BD 441-004m	15.1	17.2	19.3	19.5
BD 441-007m	15.1	15.9	18.8	17.3
BD 575-007m	15.0	16.8	18.8	19.9
BD 1354-20m	9.9	15.9	16.7	16.9
BD 1576-31m	12.4	16.7	17.1	21.1
BD 1576-07m	14.1	18.4	18.2	20.0
BD 1576-14m	14.3	17.1	15.8	17.8
N27	16.7	16.4	19.1	18.6

B47419 (check)	14.3	15.3	16.7	18.0
	NS	NS	*	*
SE±	1.7	1.1	0.9	0.9
CV%	19.8	11.2	9.1	7.8

Means were separated using SE± at P<5%.

The juice qualitative analysis reveals differences among the studied clones (Table 5). Highest fiber was recorded in some clones (BD 1098-005m, BD 441-007m, BD 1576-31 and B 47419) and the lowest fibre percent (5.37) was noted in BD 1098-003M. Those genotypes that possess high fibre can further be utilized as source for energy cane varieties since none variety had been release for such purpose in the Nigeria.

Variation among the studied hybrids for juice purity is in agreement with the report of Khan *et al*., (2017) on differences in juice purity of sixteen varieties. Juice purity above 85% with relatively high pol percent noted in some varieties indicated that these varieties attained maturity earlier than other varieties with lower purity percent. Maximum purity percent of 93.6 was obtained in BD 1576-14 and BD 1098-014m gave a lower purity level (72.6).

The disparity in the recovery sucrose of evaluated clones confirms the report of Khan *et al*., (2017). Sugar yield differs among the hybrid clones, BD 1098-001m, BD 1098-003m, and BD 1354-20m gave better sugar yield than the checks varieties (N 27 and B 47419). The family of BD 1098m clone performs better in sugar yield per hectare, which can be related to higher genetic potential of their parent for the trait. Several workers had also reported significant difference among sugarcane varieties for sugar yield per hectare (Khan *et al.*, 2017, Getaneh *et al*., 2015 and Islam *et al*., 2011).

Table 5: Juice quality of selected hybrid sugarcane genotypes evaluated at NCRI Badeggi (2018/2019)

Genotypes	Moisture (%)	Fibre (%)	Brix (%)	Sucrose (%)	Glucose (%)	Polarity (%)	Purity (%)	Recoverable Sucrose	Sugar Yield (t/ha)
BD 140-02m	67.87	10.93	21.20	20.82	26.03	19.15	89.50	11.78	12.63
BD 140-011m	67.16	12.74	20.10						
BD 140-014m	68.33	11.55	20.12	18.87	23.60	17.44	86.30	10.47	11.97
BD 1098-001m	63.01	13.99	23.00	20.39	25.50	18.59	80.80	10.65	17.47
BD 1098-003m	73.03	5.37	21.60	18.40	23.02	16.89	78.40	9.45	16.60
BD 1098-005m	57.90	16.90	25.20	22.76	28.46	21.64	85.70	12.91	11.75
BD 1098-014m	65.41	10.59	24.00	19.19	23.93	17.48	72.60	9.24	14.81
BD 441-004m	64.00	11.40	24.60	23.12	28.91	20.99	85.30	12.47	9.48
BD 441-007m	64.10	14.90	21.00	19.70	24.63	18.13	86.40	10.85	11.28
BD 575-007m	65.30	11.70	23.00	21.32	26.64	19.46	84.60	11.49	12.06
BD 1354-20m	60.45	13.05	26.50	24.79	31.04	22.25	85.40	13.08	16.31
BD 1576-31m	62.85	14.15	23.00	21.66	27.08	19.80	86.10	11.83	11.43
BD 1576-07m	66.17	12.83	21.00	18.64	23.33	17.21	81.90	9.95	9.72
BD 1576-14m	64.64	11.36	24.00	24.75	30.94	22.47	93.60	14.11	15.06
N 27	69.79	9.21	21.00	17.09	21.43	16.09	76.40	8.86	14.97
B 47419	63.59	15.21	21.20	18.37	22.98	16.91	79.70	9.59	9.33

CONCLUSION

Those clones with high fiber and good sugar yield can be dedicated for dual purposes (for sugar and ethanol production). The promising hybrids will be advance for more evaluation at diverse location for yield and juice quality stability studies.

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Water management and climate change: utilization of capillary irrigation

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ABSTRACT

In most parts of Africa where crops are grown, fertilizers and irrigation are applied to improve soil fertility status and reduce plant water stress. This is essential to reduce losses and requires effective approach in achieving adequate crop use. Application of both methods are beneficial if the value of increase in crop yield due to climatic change is sustained and improved. This study investigated the effects of urea and irrigation on the performance of *Amaranthus viridis* in the humid rainforest and savanna agroecological zones within southwestern Nigeria during two planting seasons. The experimental design was a randomised complete block design with four replicates. The treatments compared two methods of irrigation (sprinkler and capillary) with urea fertilizer application rates of 0 and 40 kg N/ ha by fertigation, broadcast, drilling and spot placement. 40 litres of water was applied at intervals during the cultivation seasons of the vegetable. In the two agroecological zones, 40 kg/ha urea-N combined with capillary irrigation significantly improved its fresh yield and other growth parameters. This method did not constitute negative effect on the vegetable quality and other agronomic parameters in both zones.

Keywords: Capillary irrigation, Agroecological zones, Fertilizer, *Amaranthus viridis*

INTRODUCTION

Irrigation is the artificial application of controlled amount of water to the soil to support crop production. Irrigation water may be applied in drops, flooding soil surface and beneath the soil.

Irrigation water may be applied to supplement the water available through irregular rainfall as a result of climatic change. It also contributes to soil moisture from groundwater. Worldwide, the amount and timing of rainfall is not adequate to meet water requirement of crops thus making irrigation important to raise crops necessary to meet food requirement in Africa. Sprinkler and capillary irrigation systems are examples of surface and subsurface irrigation methods, respectively. In the sprinkler system, water is sprayed in the air and allowed to fall on the soil by gravity. It is suitable to all types of soil and irrigate crops where the plant population per unit area is very high (Mikkelson *et al.,* 2015). Capillary irrigation as a subsurface irrigation system with the aid of capillary pipe is effective as it reduces drudgery, serves as water reservoir for plant, supplies water directly to the crop root zone and saves time (Egbebi, 2021). It will also reduce soil compaction and improve aeration which could have occurred from the effects of soil tillage. It reduces saturation and waterlogging in soil (Million *et al.,* 2007) as it provides water directly to the root zone of the soil. Irrigation practices are threatened due to increasing demand for water and its scarcity in Africa. Climatic changes and its effects is a serious challenge to agricultural development (Poonia *et al.,*2021) as increasing water demand for agricultural and industrial use has become competitive due to limited water resources (Luo *et al.,,* 2018). Many studies are also ongoing to identify the management practices which will reduce environmental threat as a result of climate change. These will be aimed to increase food production with limited and available water by improving irrigation technology as a strategy to conserve and save water. (Auci and Vignani, 2021).

METHODOLOGY

The study investigated water management under manual sprinkler (watering can) and capillary irrigation methods using *Amaranthus viridis* as test crop. It covered two successive dry planting seasons in the rainforest and savanna Agroecological zones of Nigeria. Vegetable seedlings were transplanted at spacing of 0.1 m within rows and 0.2 m between rows. Urea fertilizer was applied at two rates (0 and 40 kg N/ ha) by four different methods: fertigation, drilling, spot placement and broadcasting. 40 kg N/ha is the recommended fertilizer microdosing rate. The capillary irrigation method was combined with fertigation while the watering can sprinkler irrigation method was combined with other methods of fertilizer application and fertigation adopted for this study. Forty (40) litres of water was applied at two days interval. The treatments were as follows: **1.** 40 kg N/ ha (broadcasting) + sprinkler irrigation **2**. 40 kg N/ha (fertigation) + capillary irrigation **3**. 40 kg N/ha (spot placement) + sprinkler irrigation **4**. 40 kg N/ha (drilling) + sprinkler irrigation **5**. 40 kg N/ha (fertigation) + sprinkler irrigation **6**. 0 kg N/ha + sprinkler irrigation (control). Data on fresh biomass weight at harvest was monitored. The water required and saved to produce one kilogram of the vegetable was also determined by the irrigation methods at both locations. The data collected were analysed separated with Duncan's New Multiple Range Test with the SAS software package (SAS, 2003).

RESULTS AND DISCUSSION

The volume of water required to produce one kilogram of the vegetable reduced under the capillary irrigation method at the two locations (Table 1) compared with watering can irrigation method which was higher. This is important for vegetable production especially during this period of climate change, water scarcity, the dry season and in savanna regions (Kijazi *et al.,* 2013) where water is usually in short and limited supply. The device reduced water loss to evapotranspiration and regulated water supply to the soil root zone in response to crop demand. The control plots utilized more volume of water in this study at the two zones due to little or no application of fertilizer. However, the water used at the savanna through the manual watering can method of irrigation was significantly higher than water used at the rainforest. More water was required to produce one kilogram of the vegetable in the savanna compared with the rainforest as a result of differences in climatic variables of both locations. The is as a result of loss of some volume of water to the environment in the savanna from high solar radiation during cultivation period and water stress encountered by the vegetable. This agrees with the findings of Oyedele and Tijani (2010), who observed that temporal variation in soil water content is mainly dependent on weather conditions. This result was also influenced by the level of water applied according to Li *et al.* (2020) and the capillary irrigation device which responded precisely and actively to the vegetable root uptake with equal volume of water applied through both methods of irrigation considered. The innovation also supported water retention in the vegetable which was enough to produce optimum yield unlike the sprinkler system that encouraged runoff and fertilizer volatilization in both zones associated with climate change. The higher water requirement in the savanna is also due to higher temperature in the savanna which was in accordance to crop demand. Early shade, root and canopy development from fertigation with the capillary device combined and soil surface sealing caused by the impact of water droplets on soil surface from the sprinkler irrigation method could have reduced and increased evapotranspiration rate respectively as timely water supplied through the capillary device into the soils of these zones might have been trapped within the rhizosphere and made available for the amaranth growth and development (Table 1). These results shows that water have been saved for future agricultural and industrial use (Figure 1).

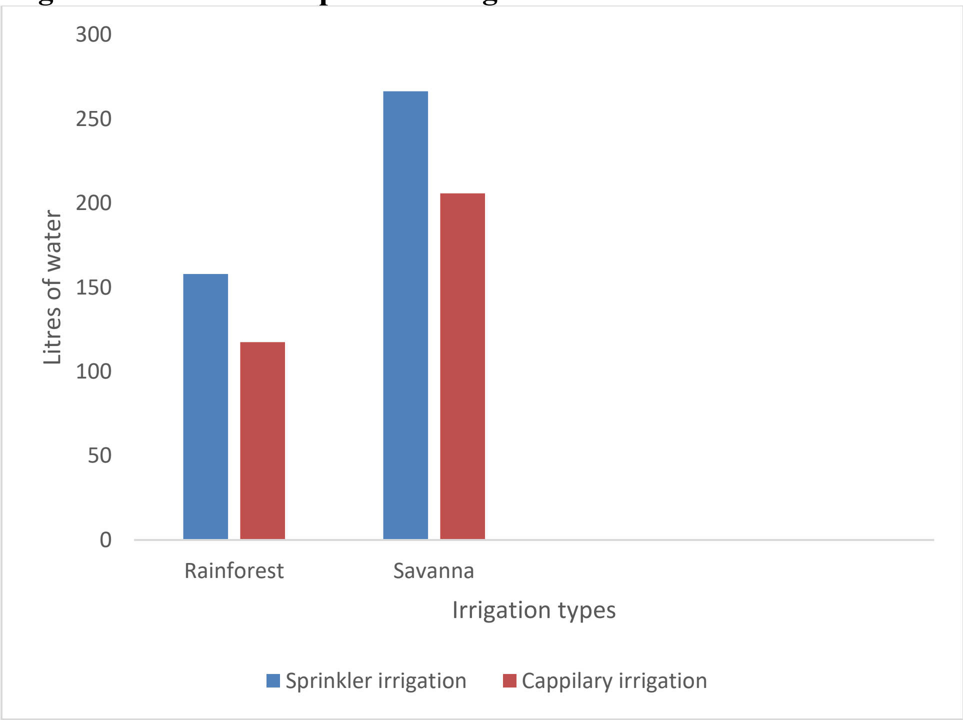
Table 1: Water required per unit weight of fresh *Amaranthus viridis*

	Rainforest	Savanna
	…...Litres…..	
1	125.32ab	234.81a
2	117.43b	205.83ab
3	133.27ab	252.43a
4	141.48ab	256.84a
5	139.32ab	261.45a
6	250.04a	326.61a

1. 40 kg N/ ha (broadcasting) + sprinkler irrigation 2. 40 kg N/ha (fertigation) + capillary irrigation 3. 40 kg N/ha (spot placement) + sprinkler irrigation 4. 40 kg N/ha (drilling) + sprinkler irrigation 5. 40 kg N/ha (fertigation) + sprinkler irrigation 6. 0 kg N/ha + sprinkler irrigation (control).

60.59 litres of water was conserved through the capillary irrigation device at the savanna while 40.45 litres was conserved at the rainforest in cultivating the green amaranth (Figure 1). Water was significantly saved through the capillary device at both zones. Climate change factors such as excessive evapotranspiration and higher temperature in both zones which could have affected and resulted to high soil infiltration rate and percolation combined with increased soil erosion from possible deforestation could have led to loss of significant amount of water from the sprinkler irrigation method adopted in the study. Higher volume of water saved at the savanna could have resulted from lower rate of decomposition of plant residue which would have retained and made water available within the root zone and reduced crop demand for water (Pregitzer and King 2005) from the capillary irrigation device. This is an advantage in this period of climate change and challenge.

Figure 1: Water saved per unit weight of fresh *Amaranthus viridis*



CONCLUSION

The capillary irrigation device has the ability to sustain and improve food production, this is evident through its water use, management and low cost of operation.

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Comparative analysis of proximate, phytochemical, mineral and antioxidant constituents of the rind, pulp and seeds of *Citrullus lanatus* Thunb. and *Cucumis melo* Linn.

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ABSTRACT
A comparative analysis of the nutritional and chemical composition of the rind, pulp and seeds of *Citrullus lanatus* Thunb. (Watermelon) and *Cucumis melo* L. (Sweet melon) was conducted with a view to ascertain the most nutritive fruit part, and to encourage whole fruit consumption and utilization. The rind, pulp and seeds of *C. lanatus* and *C. melo* were screened for their proximate, mineral, ascorbic acid and secondary metabolites contents using standard protocols while the antioxidant activity of the samples was analyzed against 1,1 – diphenyl – 2 picrylhydrazyl (DPPH) radicals and the data were subjected to variance analysis and statistically different means were separated by Duncan Multiple Range Test at $p < 0.05$. The results revealed that secondary metabolites were highest in the rind, proximate content was highest in the seeds while minerals and antioxidants activity were highest in the pulp of both fruits. The mineral composition and inhibitory antioxidant activity was discovered to be in rich amounts in Sweet melon fruit (rind, pulp and seed) which suggests that regular consumption could regulate enzyme, hormone production and control cell damage caused by free radicals. Appreciable amount of phytochemicals was recorded in the pulp of Watermelon fruit which justify its reported therapeutic potentials when consumed regularly. Therefore consumers are encouraged to consume whole fruit (rind, pulp and seed) of both fruits in enhancing health. Also Sweet melon fruit could serve as a very good substitute to Watermelon fruit when it is out of season or not readily available.

Keywords: Watermelon, Sweet melon, Rind, Pulp, Seed, Phytochemicals, Proximate, Minerals

INTRODUCTION
In Nigeria, Watermelon (*Citrullus lanatus* Thunb.) is mainly cultivated in the Guinea, Sudan and Sahel savanna vegetations and then distributed to other parts of the country. It is mostly grown for its sweet juicy taste and high water content - about 92% total weight (Okrikata and Ogunwolu, 2017). The fruit are an excellent source of vitamins having many smooth black, yellow or white compressed seeds thickened at the margin. Their seeds and pulp have been reported to contain phytochemical constituents like alkaloids, flavanoids, tannins, cardiac-glycocides, terpenoids and saponnins (Siti *et al*., 2018). The whole fruit possesses useful nutritive properties which enhance the improvement of human health and its pulp has been reported to possess high lycopene and carotenoid which are very good source of antioxidants (Adewale *et al*., 2015). Its therapeutic effects employed in the management of cancer and cardiovascular diseases has been attributed to the presence of beta carotene, lycopene, antioxidants and certain phytochemical compounds (Adewale *et al*., 2015).
Sweet melon (*Cucumis melo* Linn.) is extensively cultivated for their fruits, eaten as vegetable and sometimes naturalized in open scrub forest. The melon is reported to be rich with important vitamins such as riboflavin, thiamin, folic acid and a good source of provitamin A and C (Laur and Tian, 2011). The seed of *C. melo* are commonly used as diuretic while its pulp is used as anthelmitic while its peels has anti-hyperlipidemic effect (Naveed *et al*., 2015). The reported therapeutic, pharmacological and antioxidant properties of *C.melo* may be due to the presence of phytochemicals like tannins, saponnins, flavinoids (Alagar *et al*., 2015).

In Nigeria, the rind and seeds of *C. lanatus* and *C. melo* are largely disposed as wastes. Proper utilization of these parts (rind and seeds) could meet and improve the nutritional and therapeutic needs of consumers as well as improving environmental hygiene. Therefore this study aims to comparatively assess the proximate, phytochemical, mineral, vitamins and antioxidant constituents of the rind, seed and pulp of *C. lanatus* and *C. melo*.

MATERIALS AND METHODS

Collection, Identification and Preparation of Plant Materials

Whole fresh fruit samples of *C. lanatus* and *C. melo* were harvested from the Research Farm of Federal University Wukari, Nigeria. The pulp, seed and rind were separated, sliced to small pieces and crushed to paste using milling machine (Miller's blender) and then evaporated to dryness using water bath (model: Vega 81404).

Phytochemical Screening

The evaporated extract of *C. lanatus and C. melo* were evaluated for alkaloids, flavonoids, tannins, saponins, polyphenols, cardiac glycoscides, proximate constituents, mineral content and vitamin contents and antioxidant activity through DPPH (1, 1–diphenyl–2–picrylhydrazyl) assay using standard procedures as described by AOAC, 2005.

Statistical Analysis

Data were subjected to variance analysis using SPSS version 23 and significantly different means were separated by Duncan Multiple Range Test (DMRT) at $p < 0.05$ or 95% confidence interval.

RESULTS AND DISCUSSION

Table 1 shows that the phytochemical constituents displayed in the fruit parts were highest from rind > pulp > seed in the descending order. It further shows significantly higher secondary metabolites in Sweet melon than Watermelon fruits in most analytes. The phytochemical analysis of the rind (Table 1) showed that the rind of Sweet melon (SM) displayed significantly higher constituents except for terpenoid (576.67±6.00 mg/100g) present in the rind of Watermelon (WM), while the seed and pulp of both plants displayed appreciable amount of secondary metabolites.

Table 1: The phytochemical composition of the rind, pulp and seeds of sweet melon and watermelon fruits

	Phytochemical composition (mg/100g)					
Variable	**Alkaloid**	**Flavonoid**	**Cardiac glycosides**	**Saponins**	**Tannins**	**Terpenoids**
RIND (SMR)	$1718.30±7.26^{a}$	$188.33±4.41^{b}$	$76.67±1.67^{a}$	$328.33±4.41^{b}$	$246.67±6.00^{b}$	$51.67±1.77^{e}$
(WMR)	$1695.00±7.63^{b}$	$105.00±2.89^{c}$	$11.67±1.65^{c}$	286.67±3.41c	$241.76±7.26^{b}$	$576.67±6.00^{a}$
PULP (SMP)	$455.00±7.63^{d}$	$316.\ 67±6.01^{a}$	$63.33±1.\ 76^{b}$	$216.67±4.40^{d}$	$216.67±6.01^{c}$	$33.33±1.67^{f}$
(WMP)	$546.67±9.27^{c}$	$331.67±7.26^{a}$	$20.00±2.89^{c}$	$328.33±6.01^{b}$	$320.00±2.89^{a}$	$518.33±4.41^{b}$
SEED (SMS)	$371.67±6.00^{e}$	$45.00±2.89^{d}$	$16.67±4.41^{c}$	$118.33±4.41^{e}$	$56.67±4.44^{e}$	$206.67±3.95^{d}$
(WMS)	$186.67±5.36^{f}$	$33.33±4.41^{d}$	$11.76±1.46^{c}$	$386.56±5.99^{a}$	$131.57±6.10^{d}$	$468.34±4.00^{c}$
P- value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Values are expressed as Means ± SE; Means with same alphabet across the column are not significantly different at $p<0.05$; **SMR** = Sweet melon rind; **WMR** = Watermelon rind; **SMP** = Sweet melon pulp; **WMP** = Watermelon pulp; **SMS** = Sweet melon seed; **WMS** = Watermelon seed.

The proximate analysis revealed that their quantitative nutrient composition (carbohydrates, proteins and fats) was highest from seeds > rind > pulp in the descending order as shown in table 2. Generally the result from this study shows that Sweet melon fruit displayed an overall higher significant nutrient composition than Watermelon. The nutrient composition of SMR had significantly higher carbohydrate (5.07±0.04%), ash (0.97±0.01%) while WMR displayed significantly higher moisture content (94.12±0.02%), lower ash (0.69±0.01%) contents (table 2). The carbohydrate (6.08±0.03%), ash (0.60±0.02%) and crude fat (0.03±0.00%) of SMP displayed higher composition than WMP except for its moisture content (95.03±0.12%) as shown (table 2). Except for moisture content (67.29±0.03%) and carbohydrate (18.02±0.54%) composition in WMS was significantly ($p < 0.01$) higher than SMS, the other proximate parameters were higher in SMS vis-à-vis WMS (Table 2).

Table 2: Proximate composition of the rind, pulp and seeds of sweet melon and watermelon fruit

Variable	Proximate composition (%)					
	Moisture Content	Protein	Fat	Ash	Fiber	Carbohydrate
RIND (SMR)	92.17±0.01^{d}	1.60±0.01^{c}	0.18±0.01^{c}	0.97±0.01^{c}	1.54±0.02^{d}	5.70±0.04^{d}
(WMR)	94.12±0.02^{b}	1.61±0.23^{c}	0.09±0.01^{d}	0.69±0.01^{d}	1.86±0.01^{b}	3.48±0.01^{f}
PULP (SMP)	92.60±0.01^{a}	0.68±0.01^{e}	0.03±0.00^{e}	0.60±0.02^{e}	0.23±0.00^{f}	6.08±0.03^{c}
(WMP)	95.03±0.12^{a}	0.74±0.02^{d}	0.02±0.00^{b}	0.37±0.02^{f}	1.61±0.00^{c}	3.84±0.03^{e}
SEED (SMS)	62.79±0.02^{f}	10.07±0.25^{a}	9.48±0.01^{a}	1.60±0.01^{a}	10.24±0.25^{a}	16.05±0.02^{b}
(WMS)	67.29± 0.03^{e}	7.66±0.05^{b}	5.93±0.02^{c}	1.10±0.07^{b}	1.08±0.03^{e}	18.02±0.54^{a}
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Values are expressed as Means ± SE; Means with same alphabet across the column are not significantly different at p<0.05; **SMR** = Sweet melon rind; **WMR** = Watermelon rind; **SMP** = Sweet melon pulp; **WMP** = Watermelon pulp; **SMS** = Sweet melon seed; **WMS** = Watermelon seed.

Table 3 shows that the fruit parts possessed appreciable mineral constituents. The mineral composition of the SMR was significantly higher than WMR for all parameters except potassium (3656.70±34.87 mg/100g) while the pulp and seed displayed varied amount of minerals.

Table 3: Mineral composition of the rind, pulp and seeds of sweet melon and watermelon

Variable	Mineral composition (mg/100g)					
	Calcium	Iron	Zinc	Magnesium	Potassium	Phosphorus
RIND (SMR)	1454.30±5.78^{c}	15.18±0.37^{a}	3.45±0.40^{d}	2253.70±4.12^{a}	3106.00±15.56^{b}	474.25±2.04^{a}
(WMR)	1050.00±14.49^{d}	6.65±0.23^{b}	3.20±0.02^{e}	914.77±2.12^{b}	3656.70±34.87^{a}	445.27 ±2.47^{c}
PULP (SMP)	1945.00±2.94^{a}	2.46±0.01^{e}	1.10±0.20^{f}	84.45±0.42^{e}	3090.30±20.18^{b}	193.80±0.83^{e}
(WMP)	1635.90±10.92^{b}	4.15±0.15^{c}	4.39±0.70^{b}	73.42±1.26^{f}	2053.40±26.09^{c}	301.48±5.94^{d}
SEED (SMS)	440.16±5.92^{f}	6.67±0.39^{b}	4.58±0.01^{a}	194.40±1.81^{d}	1541.70±10.99^{d}	479.27±1.99^{a}
(WMS)	745.13±3.00^{e}	3.78±0.35^{d}	4.06±0.02^{c}	257.69±3.87^{c}	562.22±5.63^{e}	460.30±1.54^{b}
P-value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Values are expressed as Means ± SE; Means with same alphabet across the column are not significantly different at p<0.05; **SMR** = Sweet melon rind; **WMR** = Watermelon rind; **SMP** = Sweet melon pulp; **WMP** = Watermelon pulp; **SMS** = Sweet melon seed; **WMS** = Watermelon seed.

The scavenging property of fruits was highest from pulp › rind › seed in the descending order as shown in table 4. The Ascorbic acid (22.53±0.24 mg/100g), Phenols (87.43±0.12 mg/100g) of WMP were significantly ($p < 0.01$) higher than those in SMP. The antioxidant inhibitory potential (69.70±0.14%) SMP was also significantly ($p < 0.01$) higher than that of WMP (table 4). The amount of phenol, ascorbic acid and antioxidant inhibition in the peel and seeds of both fruits shows promising potentials of all fruit parts in scavenging free radicals.

Table 4: Antioxidants and ascorbic acid composition of rind, pulp and seeds of sweet melon and watermelon fruits

Variable	Ascorbic (mg/100g)	Phenols (mg/100g)	Antioxidant inhibition (%)
RIND (SMR)	25.90±0.38^{b}	87.80±0.21^{a}	72.60±0.15^{a}
(WMR)	30.37 ±0.20^{a}	15.27±0.18^{d}	5.53±0.12^{f}
PULP (SMP)	15.27±0.12^{e}	85.37±0.15^{b}	69.70±0.14^{b}
(WMP)	22. 53± 0.14^{c}	87.43±0.12^{a}	68.57 ±0.16^{c}
SEED (SMS)	12.56±0.12^{f}	32. 53±0.14^{c}	10.43±0.13^{d}
(WMS)	18.37±0.21^{d}	14.56±0.15^{e}	8.23±0.25^{e}
P-value	<0.01	<0.01	<0.01

Values are expressed as Means ± SE; Means with same alphabet across the column are not significantly different at p<0.05; **SMR** = Sweet melon rind; **WMR** = Watermelon rind; **SMP** = Sweet melon pulp; **WMP** = Watermelon pulp; **SMS** = Sweet melon seed; **WMS** = Watermelon seed.

Generally, Sweet melon (*C. melo*) and Watermelon (*C. lanatus*) pulp are consumed for their sweet taste while their seeds and peels discarded. This study evaluated the rind, pulp and seeds of these fruits and found that they possess appreciable amount of phytochemical, proximate, minerals contents with promising antioxidants potentials. The quantitative phytochemical screening of the rind, pulp and seeds of Sweet melon (*C. melo*) and Watermelon (*C. lanatus*) fruits revealed that they possess significant amount of alkaloids, flavonoids, cardiac glycoscides, tannins and terpenoids that are known to exhibit therapeutic and pharmacological properties as reported by Anandhi and Revathi (2013). The consumption of these plant chemicals may help to prevent some cancer ailments, as well as other serious ailments such as heart diseases, kidney disorders, liver damage and promote better blood functions.

Generally the rind and seeds of Sweet melon and Watermelon are discarded because they are regarded as waste but the highest fiber content from this study was observed in the seed followed by the rind and least in the pulp which suggest that a wide range of useful macromolecules, secondary metabolites and nutritional components that could be harnessed from these plant parts. Therefore, the consumption of the seed, rind with the pulp of Sweet melon and Watermelon have the potential to increase the numerous dietary fiber benefits of these fruits such as protection against colon cancer, maintaining blood lipids within the normal range, reducing the risk of obesity by lowering cholesterol level, hypertension, cardiovascular diseases as well as aid smooth functioning of intestinal tissues (Khan *et al*., 2013). It was observed that a rise in the phenol content showed a corresponding rise in inhibition against DPPH free radicals in Sweet melon rind, Watermelon pulp and Sweet melon seeds. Therefore regular consumption of plants with appreciable antioxidant activity or potentials such as Sweet melon and Watermelon could reduce the reactive oxygen species (ROS) capable of causing decrease in membrane fluidity, loss of enzyme receptor activity, damage to membrane protein, cancer, cardiovascular diseases, diabetes, rheumatoid arthritis, epilepsy, degradation of essential fatty acids and death (Li *et al*., 2007).

CONCLUSION

This study revealed that Sweet melon (*C. melo*) and Watermelon (*C. lanatus*) rind, pulp and seeds possess beneficial phytochemical, nutritional and mineral components and that Sweet melon had higher nutrients, secondary metabolites and minerals than Watermelon. Also, the rinds of the fruits housed highest phytochemicals, its seeds; the proximate and the pulp; mineral contents and antioxidant activity. The fruit could thus exhibit therapeutic function due to the high phytochemicals present (alkaloids, flavonoids, tannins) in the rind, serve as nutritional supplement because of the proximate constituent (crude fibre, protein, carbohydrate) present in the seeds while the presence of appreciable minerals (calcium, potassium, magnesium) and high antioxidant activity (phenol, ascorbic acid) in the pulp could neutralize ROS and improve body metabolism. Therefore consumers are advised not to discard peel and seed but encouraged to consume whole fruit in order to harness the total nutritional and medicinal benefits from these fruit.

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An Assessment of the portion of stem on the yield of cassava (NR 8082) under Umudike Agro-ecology.

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ABSTRACT
Investigations were conducted to study the assessment of stem portion on the yield of cassava (NR 8082) under Umudike agro ecology during the 2019/2020 and 2020/2021 cropping seasons. In each year, the experiment was a 3 x 3 factorial laid out in a randomized complete block design (RCBD) with three replicates. Treatments comprised three stem portions (top, middle and tail) and three numbers of stakes per stand (1, 2 and 3). The top portion of the stem gave the best stem portion for storage root yield. However, the top portion produced the highest yield on average. The use of 1 stake per stand increased number of storage roots per plant, root weight and storage root yield in 2020/2021 cropping season. Number of stakes per stand did not significantly influence storage root yield across the two cropping seasons. Findings from this study showed that the use of 1 stake per stand is recommended for high root yields of NR 8082 cassava variety in Umudike agro ecology.
Key words: portion of stem, yield, cassava, Umudike, agro-ecology.

INTRODUCTION
Cassava, (*Manihot esculentus* Crantz) is a very important crop in Nigeria and many countries of the world. According to Food Safety Network (2014), it is known as the third most important source of calories in the tropics after rice and maize. It is also a raw material based for some industries in the production of many finished products. It can be processed into different forms of food for human consumption and in feeding livestock. The demand for cassava is expected to increase as consumers changes with the development of new cassava products (Alacho *et al.*, 2013) but farmers' fields are low due to inappropriate agronomic practices and poor or low soil fertility (Okpara *et al.*, 2010
Number of shoots per stand of cassava is likely to influence growth, development and the yield stability in cassava either by competitions between these shoot for nutrients and space. When cassava stakes are been planted, they produce many shoots which gives rise to nutrient competition. This competition may lead to reduction in shoots. This study seeks to explore ways of integrating the best stem portion and number of stakes per stand to maximize yield. The objective of this study was therefore to investigate the assessment of the portion of stem on the yield of cassava (NR 8082) under Umudike agro-ecology.

MATERIALS AND METHODS
The study was conducted during the 2019/2020 and 2020/2021 cropping seasons at the National Root Crops Research Institute (NRCRI), Umudike farm, Southeastern Nigeria. Umudike is located on Latitude 5^{o} 29$^{'}$ N, Latitude 7^{o} 32$^{'}$ E and altitude of 122meters above sea level.
The study was a 3 x 3 factorial experiment laid out in a randomized complete block design (RCBD) with three replicates. Three levels of cassava stem portions (top, middle and tail) and three levels of number of stakes per stand (1, 2 and 3 stakes). Each plot size measured 5m x 6m (30m^2). The cassava stems were cut and separated into different stem portions (top, middle and tail). The cassava stakes were planted on the crest of the ridges, using the inclined or slanting method at an angle 45^0 to the ground level. While planting, buds faced upwards and two-third buried into the ridges. The planting space at 1m x 1m which gave a plant population of 10,000 plants per hectare for 1 stake per plant, 20,000 plants per hectare for 2 stakes per plant and 30,000 plants per hectare for 3 stakes per plant. After planting,

the field was sprayed with pre- emergence herbicide (EL-TARAZINE), 150mls diluted in 20L of water and post emergence herbicide (TACKLE), 200mls in 20L water to check weeds. Data for yield parameters were taken on number of storage roots, storage root weight per plant (kg) and root yield (t/ha) at 12 MAP in both cropping seasons. The data obtained were subjected to analysis of variance (ANOVA) using GenStat Discovery (2007) edition and the treatment means were separated using Fisher's Least Significant test at 5% probability level.

RESULTS AND DISCUSSION

In **Table 1,** there were no significant effects of stem portion on number of storage roots in both cropping seasons**.** The number of stakes per stand had significant effect, such that 1 stake gave higher number of tuberous roots than 2 or 3 stakes per stand. 2 and 3 stakes per stand maintained statistically similar number of storage roots in both cropping seasons. There were no significant interactions between stem portion and number of stakes per stand on the number of storage roots produced. In **Table 2** in both cropping seasons, top stem portions had significantly higher storage weight per plant than the middle or tail stem cuttings. The middle and tail stem cuttings did not vary in tuberous root weight. In both seasons, interactions were not significant on root weight per plant. In both cropping seasons in **Table 3**, storage root yield in tons per hectare followed similar trends in response to stem portion**.** However, in 2019/2020, the top stem portion produced a significantly higher root yield than the middle and tail cuttings. Storage root yields of the middle and tail stem cuttings were not significantly different in both seasons. There were no differences in storage root yield with respect to number of stakes in 2019/2020, but in 2020/2021, 1 stake per stand had significantly higher root yield than planting 2 and 3 stakes per stand. The 2 and 3 stakes per stand maintained comparable root yields.

Stem portion had effect on storage root yield, with gave the highest yield that was obtained from the top portion. According to Legese *et al.,* (2011), he also reported similar trends. In order to improve the rooting and consequently the establishment of the top portion which produced optimum yield, Onwueme and Sinha (1991) stressed that it is needed to allow tender shoot tips root in mist chamber before transplanting them to the field. The yields of fresh storage root were also the highest with 1 stake per stand in one year. However, the root weight and the number of storage roots decreased as the population density increased. This tells us that number of tubers and tuber weight per plant were dictated by competiting with neighboring plants for light and nutrient. According to Okpara *et al*, (2014) it was observed that when competition became intense in yam, it limits the availability of environmental resources to individual plants. It also leads to high intra plant competition for assimilates which leads to reduction in the number and the weight of tubers.

CONCLUSION

Form this investigation, the soil type makes us to know that the use of more than one stake per stand is not necessary since because there is no improvement in the yield. Conclusively, under the condition of this study, the results showed that stem portion had significant effects on cassava storage root weight and yield. However, the top stem portion produced the highest root yield and is recommended. Therefore, it is recommended that 1 stake per stand should be adopted for cassava production under Umudike agro-ecology.

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Table 1: Effect of portion of stem and number of stakes per stand on number of storage roots per plant.

	Number of stakes per stand			
Stem portion	1	2	3	Mean
		2019/2020		
Top	10.20	7.67	6.93	**7.27**
Middle	9.43	4.63	4.23	**5.10**
Tail	10.50	5.57	4.27	**5.78**
Mean	**10.04**	**5.96**	**5.14**	**6.05**
		2020/2021		
Top	10.27	6.47	3.73	**6.82**
Middle	9.90	7.20	5.53	**7.54**
Tail	15.27	7.10	5.90	**9.42**
Mean	**11.81**	**6.92**	**5.06**	**7.93**

		2019/2020	**2020/2021**
LSD $_{(0.05)}$ for portion of stem (P) means	=	NS	NS
LSD $_{(0.05)}$ for number of stakes (S) means	=	1.97	2.40
LSD $_{(0.05)}$ for P x S means	=	NS	NS

Table 2: Effect of the portion of stem and number of stakes per stand on storage root weight (kg) per plant.

	Number of stakes per stand			
Stem portion	**1**	**2**	**3**	**Mean**
		2019/2020		
Top	0.519	0.495	0.387	**0.467**
Middle	0.251	0.308	0.391	**0.317**
Tail	0.402	0.276	0.219	**0.299**
Mean	**0.391**	**0.360**	**0.332**	**0.361**
		2020/2021		
Top	0.494	0.341	0.288	**0.374**
Middle	0.330	0.235	0.211	**0.259**
Tail	0.265	0.235	0.199	**0.233**
Mean	**0.363**	**0.270**	**0.233**	**0.289**

		2019/2020	**2020/2021**
LSD $_{(0.05)}$ for portion of stem (P) means	=	0.143	0.057
LSD $_{(0.05)}$ for number of stakes (S) means	=	NS	0.057
LSD $_{(0.05)}$ for P x S means	=	NS	NS

Table 3: Effect of portion of stem and number of stakes per stand on storage root yield (t/ha).

	Number of stakes per stand			
Stem portion	1	2	3	Mean
		2019/2020		
Top	46.9	65.1	56.1	**56.0**
Middle	20.8	20.4	37.6	**26.3**
Tail	36.6	25.3	21.9	**27.9**
Mean	**34.8**	**36.9**	**38.5**	**36.7**
		2020/2021		
Top	47.8	37.6	23.3	**36.2**
Middle	28.3	29.2	28.5	**28.7**

Tail	37.0	28.7	29.3	**31.7**
Mean	**37.7**	**31.8**	**27.0**	**32.2**

		2019/2020	2020/21
LSD $_{(0.05)}$ for portion of stem (P) means	=	14.35	NS
LSD $_{(0.05)}$ for number of stakes (S) means	=	NS	8.70
LSD $_{(0.05)}$ for P x S means	=	NS	NS

Insecticidal effects and benefits on crop production in Nigeria.

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ABSTRACT
Insecticides are chemicals used in the controlling of insects to prevent them from destroying our farm produce. Some are systemic while some are toxic to our crops. An insect can be defined as a small animal of class **Insecta** or **hexapoda** of arthropods like bugs, ants, beetles, butterflies or bees with well-defined head, thorax, and abdomen. Pesticide covers a wide range of compounds which are insecticides, fungicides, herbicides, rodenticides, molluscicides and nematicides. Some pesticides are beneficial to our crops while some are hazardous to our crops. Due to this, instead of using chemical insecticides, there are many alternative options available now that can protect farmers from major economic losses such as breeding crops resistance, using chemical control like pheromones, integrated pest management and pull push technique methods must be adopted.
Key words: insecticidal, effects, benefits, crop production, Nigeria.

INTRODUCTION
Insecticides are chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors. They are used to kill insect. Insecticides are classified based on their structure and mode of action, many of them act upon the insect's nervous system such as cholinesterase, inhibition etc while others act as growth regulators. Insecticides are commonly used in agricultural, public health and industrial applications, as well as household and commercial uses in the control of roaches and termites. The most commonly used insecticides are the organophosphates, pyrethroids and carbamates . The USDA (2001) reported that insecticides accounted for 12% of total pesticides applied to the surveyed crops. Insecticides are applied in various ways, formulations and delivery systems that influence their transport and chemical transformation. Insecticides can be done through runoff , atmospheric deposition, or sub-surface flow (Moore and Ramamoorthy 1984). This study aims to know the way we can control our farm crops in order not to be affected or destroyed while applying insecticide to it.

Types of insecticides
There are two types of insecticides, namely: Systemic insecticides and the contact insecticides.

Systemic insecticides: It become incorporated and distributed systemically throughout the whole plant. When insects feed on the plant, they ingest the insecticide. Systemic insecticides produced by transgenic plants are called plant-incorporated protectants (PIPs).

Contact insecticides: They are toxic to insects upon direct contact and can be inorganic insecticides, which are metals and include the commonly used sulfur, and the less commonly used arsenates, copper and fluorine compounds. Contact insecticides can also be organic insecticides, i.e. organic chemical compounds, synthetically produced, and comprising the largest numbers of pesticides used today.

THE TABLE BELOW SHOWS INSECTICIDE TYPES AND THEIR MODE OF ACTION

Insecticide	Mode of Action
Organophosphate	Cause acetylcholinesterase inhibition and accumulation of acetylcholine at neuromuscular junctions causing rapid twitching of voluntary muscles and eventually paralysis. A broad-range insecticide, generally the most toxic of all pesticides to vertebrates.
Organosulfur	Exhibit ovicidal activity (i.e., they kill the egg stage). Used only against miteswith very lov toxicity to other organisms.
Fumigants	Act as narcotics that lodge in lipid-containing tissues inducing narcosis, sleep or unconsciousness; pest affected depends on particular compound.
Benzoylureas	Act as insect growth regulators by interfering with chitin synthesis. Greatest value is in the control of caterpillars and beetle larvae but is also registered for gypsy moth and mushroon fly. Some types are known for their impacts on invertebrates (reduced emergent species) ar early life stages of sunfish (reduced weight) (Boyle et al. 1996).
Antibiotics	Act by blocking the neurotransmitter GABA at the neuromuscular junction; feeding and eg laying stop shortly after exposure while death may take several days. Most promising use c these materials is the control of spider mites, leafminers and other difficult to control greenhouse pests.
Organosulfur	Exhibit ovicidal activity (i.e., they kill the egg stage). Used only against mites with very lov toxicity to other organisms.
Pyrethroids	Acts by keeping open the sodium channels in neuronal membranes affecting both the peripheral and central nervous systems causing a hyper-excitable state. Symptoms include tremors, incoordination, hyperactivity and paralysis. Effective against most agricultural insect pests; extremely toxic to fish.
Carbamates	Cause acetylcholinesterase (AChE) inhibition leading to central nervous system effects (i.e rapid twitching of voluntary muscles and eventually paralysis). Has very broad spectrum toxicity and is highly toxic to fish.

From Radcliffe et al. (2009).

A crop duster airplane spraying a field with insecticides. Aerial drift of insecticides can cover long distances depending on wind and other factors.

Some biological effects of insecticides

- Developmental effects, especially in aquatic insects (Kreutzweiser 1997).
- Sudden, massive kills of aquatic life (e.g., fish kills)
- Fish exhibiting cough, yawn, fin flickering, S-and partial jerk, nudge and nip; difficulty in ventilation and aberrant behavior (Alkahem 1996)
- Reduced biological diversity (Relyea 2005), especially among aquatic insects.

- More natural insecticides have been interesting targets of research for two reasons, one of it is that the most common chemicals are losing effectiveness, and also, due to their toxic effects upon the environment, many organic compounds are already produced by plants for the purpose of defending the host plant from predation and can be turned toward human ends.

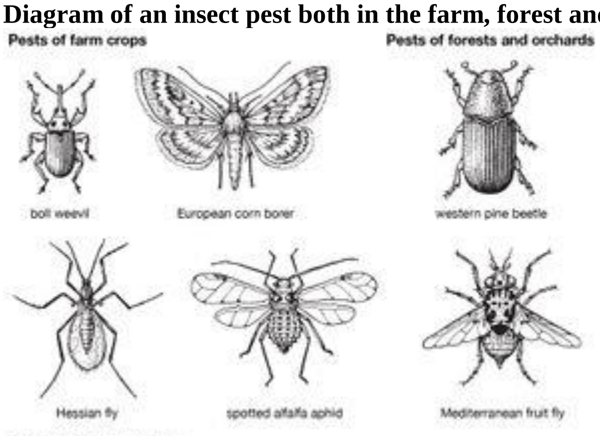
An Insect: An insect can be defined as a small animal of class **Insecta** or **hexapoda** of arthropods like bugs, ants, beetles, butterflies or bees with well-defined head, thorax, and abdomen. The legs are only three pairs (six legs) and with one or two pairs of wings. They are usually refered to as disease carriers but some of them are beneficial to plants. In adaptability, insect is the most successful group of animals. Also, the insect orders that have the greatest numbers of species are the beetles, wasps, bees, butterflies etc. They are adapted to any habitat or environment either land or fresh waters.

Importance of insect: It plays many roles on our crop and for we human being. Some insect like bees produces honey, wax, silk and dyes and they are of a good benefit to the human being. Some insects also serve as food for some people such as termite swams, large palm weevil grubs are source of protein. Some insect can also cause damage to our agricultural products because of their feeding on different types of organic matter. Insect pests affect our food crops both in the field and while storing them and it makes them convey infective micro organisms to the crops.

ENVIRONMENTAL HARM OF INSECT PEST DAMAGE TO CROPS AND COMMERCIAL PRODUCTS.

Some insecticides kill or harm other creatures in addition to those they are intended to kill. For example, birds may be poisoned when they eat food that was recently sprayed with insecticides or when they mistake an insecticide granule on the ground for food and eat it. (Palmer *et.al*., 2007). Sprayed insecticide may drift from the area to which it is applied and into wildlife areas, especially when it is sprayed aerially. In hot and dry areas, as in Southeastern Nigeria, matured tuber crops in the fields is affected by beetles and moths and when it is been harvested, these insects multiplies in the store. They can be carried throughout till the next cropping season. Disinfecting is the best method used to control the insect pest. Some insects feed on the plant and when the plants are of agricultural importance, humans are often forced to compete with these insects. In some agricultural sector, insect pests were introduced along with a crop while planting in the field.

Diagram of an insect pest both in the farm, forest and ochard.



Pesticide: Pesticide covers a wide range of compounds which are insecticides, fungicides, herbicides, rodenticides, molluscicides and nematicides. Among all, insecticides are used in the control of insect diseases. Other systemic insecticides called organophosphate (OP) was introduced in the 1960s, carbamates 1970s and pyrethroids in 1980s. A pesticide is used to target a particular pests and not to non-target pests. Pesticides can be absorbed by plants through the leaves and roots. The ones that are taken up by plants can move (translocate) to other parts of the plant.

Benefits of pesticides

The main benefit of pesticides is the positive effect of it on the agricultural crops.

- For instance, it improves the productivity by killing caterpillars that are feeding on the crop in order not to reduce the yield during harvesting period.
- It also improves the productivity of the farmers such as grains, roots and tuber crops, legumes.
- Food grain production increases from 50million tons (1948-1949) from 169 million tons (1996-1997). This was achieved by making use of high yielding seed materials, advanced irrigation techniques as well as agricultural chemicals (Employment Information: Indian Labour Statistics, 1994).
- Other benefits are: By protecting crop losses, controls of vector diseases and provision of good quality food. In the environment, most of the pesticides undergo photochemical transformation to produce metabolites which are not harmful to human beings and the environment (Kole *et al*., 1999).

Hazard effect of pesticides

- One of it is by contact direct to man and his environment. While applying the pesticides to the infected plant, it can also affect the person that is spraying it and the entire environment. According to Environews Forum, (1999), it was stated that the world-wide deaths and chronic diseases was due to pesticide poisoning number which is about 1 million per year in which the production workers, formulators, sprayers, mixers, loaders and agricultural farm workers are exposed to the high risk of the pesticides.

- **The effect of Pesticide on the environment: It can also contaminate the soil, water and other vegetation by killing weeds. It can be toxic to other organisms host like: birds, fish, beneficial insects, and non-target plants.**

- **Effect of pesticide on soil fertility: According to soil scientist, Dr. Elaine Ingham, it was stated that the soil will be degrade if we lose the bacteria and the fungi present in the soil. This will happen due to the over use of pesticides which had effect on the soil organism.**

- **Runoff and Percolation: Solid bait and liquid insecticides, especially if improperly applied in a location, get moved by water flow. This happens through nonpoint sources where runoff carries insecticides in to larger bodies of water. As snow melts and rainfall moves over and through the ground, the water picks applied insecticides and deposits them in to larger bodies of water, rivers, wetlands, underground sources of previously potable water, and percolates in to watersheds. This can effect the quality of water sources, harming the natural ecology.**
- Insecticides can kill bees and may be a cause of pollinator decline, the loss of bees that pollinate plants, and colony collapse disorder in which worker bees from a beehive or Western honey bee colony abruptly disappear.

CONCLUSION

Pesticides are very easy and quick solution for controlling weed insect pests in our farms. However, it has contaminated almost every part of our environment. The residues are still present in the soil, air and in ground water across the countries. Pesticide contamination had a great risk to the environment and non-target organisms ranging from beneficial soil microorganisms, to insects, plants, fish, and birds. Therefore, Instead of using chemical insecticides to avoid crop damage caused by insects, there are many alternative options available now that can protect farmers from major economic losses. They are:

- Breeding crops resistant.

- Releasing predators, parasitoids, or pathogens to control pest populations as a form of biological control.

- **Chemical control like releasing pheromones into the field to confuse the insects into not being able to find mates and reproduce.**
- **Integrated Pest Management: The act of using multiple techniques in tandem to achieve optimal results.**
- **Push-pull technique: Intercropping with a "push" crop that repels the pest, and planting a "pull" crop on the boundary that attracts and traps it.**

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Agronomic Response of Maize (Zea mays L.) Varieties to Nitrogen Fertilization in a Tropical Rainforest Agro-ecology

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ABSTRACT

Field trial was carried out during the early growing season of 2019 and 2020 at Benin City in Tropical rainforest of Nigeria, to evaluate the agronomic performance of maize varieties to varying rates of nitrogen fertilization. The experiment was laid out in a randomized complete block design, with a split-plot arrangement. Main plot treatment was nitrogen (N) rate (0, 30, 60, 90 and 120 kg N ha^{-1}) and subplot treatment was maize variety (TZEE-Y POP STR C4, 2008 DTMA - Y STR, BR. 9928 DWRSR and TZL COMP.4 C4). Results showed lack of significant N rate × variety interactions for traits except 1000-seed weight. Maize performance was influenced by N rate and variety. Grain yields were higher by 32, 57, 56 and 61% at 30, 60, 90 and 120 kg N ha^{-1} respectively compared to 0 kg N ha^{-1}. Optimum performance was achieved for grain yield at 60 kg N ha^{-1} beyond which rate, additional N did not cause any significant increase. TZL COMP.4 C4 and BR.9928 DWRSR out-yielded TZEE-Y POP STR C4 and 2008 DTMA-Y STR. Therefore, in the Tropical rainforest agro-ecology, TZL COMP.4 C4 and BR.9928 DWRSR should be grown at 60 kg N ha^{-1} for optimum yield.

Keywords: Nitrogen (N) rate; maize variety; grain yield; rainforest agro-ecology

INTRODUCTION

Maize (*Zea mays* L.) is a major cereal crop cultivated in Nigeria. Owing to its high demand, maize is the most widely grown staple food crop in sub-Saharan Africa (SSA), occupying more than 34 million hectares each year (Food and Agriculture Organisation, 2012). Despite the vast land and number of maize farmers in Nigeria, the crop harvest is low due to poor yields. The Tropical rainforest zone of Nigeria has a great potential for maize production, but this is not often realized because the soils are particularly poor in available nitrogen (N).

The high demand of maize for N and other major nutrients such as phosphorus (P) and potassium (K) makes it impossible to achieve high maize yield without fertilization (Havlin et al., 2013). Nitrogen is typically the nutrient of most concern because it has a strong influence on cereal crop yields (Havlin et al., 2013). However, N deficiency is common in the Tropical rainforest zone of Nigeria due to N losses through excessive run offs, leaching and volatilization. Therefore, soils in this region cannot support meaningful maize yields without proper N fertilization. Continuous and excessive application of N fertilizer has negative effects on crops, and as such, hindering agricultural and environmental sustainability. However, Kamara et al. (2004) suggested that one strategy for improving the productivity of maize is to select varieties that perform well under suboptimal N conditions.

A sustainable approach, such as assessing maize varieties that does well at an applied N level maybe the best agronomic practice for the sustainability of maize and the environment with the growing human population. Maize varieties of different maturities are recently being introduced into the Tropical rainforest zone. The Tropical rainforest is traditionally known to be a zone where late maturing maize varieties are grown. Most of the farmers use single rate of N for all maize maturities since there is little or no information available on the rate of N application for various maize maturity groups. Availability of maize of different maturities can change the optimum or recommended rate of N. Thus with the introduction of maize of diverse maturities into the rainforest, there is need to know how these varieties will perform under varying rates of N fertilization. This may result in identification of correct nitrogen rate for particular varieties for optimum yields. Therefore, the objective of this study was to determine the agronomic performance of contrasting maize varieties to varying rates of nitrogen fertilization in a Tropical rainforest agro-ecology.

MATERIALS AND METHODS

The study was conducted during the rainy seasons of 2019 and 2020 at the Teaching and Research Farm of the Faculty of Agriculture, University of Benin, Benin City, in the Tropical rainforest of Nigeria. The physical and chemical properties of the soil at the experimental site were determined at the beginning of the experimentation in 2019 according to procedures of International Institute of Tropical Agriculture (1982).

Maize varieties evaluated in this study were: TZEE-Y POP STR C4, extra-early maturing; 2008 DTMA - Y STR, early maturing; BR. 9928 DWRSR, intermediate maturing and TZL COMP.4 C4, late maturing. The experiment was laid out in a randomized complete block design with a split-plot arrangement replicated three times. Treatments were nitrogen rate (0, 30, 60, 90 and 120 kg N ha^{-1}) and the four maize varieties. Nitrogen rate formed the main plot and maize varieties the subplots. A subplot measured 3.0 m x 5.0 m having four rows. Treatment plots and replications were separated by 0.75 m.

After land preparation, three seeds of maize were sown per hole at a depth of about 4 - 5 cm at a plant spacing of 75 cm x 25 cm. Seedlings were thinned to one plant per stand, two weeks after planting.

At one week after planting, phosphorus was applied as single super phosphate (SSP) at a rate of 60 kg ha^{-1} P_2O_5 and potassium was applied as muriate of potash (MOP) at a rate of 60 kg ha^{-1} K_2O, to all plots. Urea was used as a source of nitrogen. Half of each nitrogen treatment rate was applied one week after sowing and the remaining half at three weeks after the first application. Weed and insect pest were properly managed.

Data were collected from the two middle rows per plot (net plot). At full tasselling, plant height (cm) was determined on five randomly selected plants, by measuring the height from ground level to the node, where the last top leaf (flag leaf) attached itself to the stem just before the tassel using a measuring rule. The average plant height was recorded. At maturity, plants in a net plot were harvested for the determination of yield and yield components. Harvested ears were de-husked and air-dried for one week. Grains were threshed from the dried cobs and, weighed. Grain yield was expressed in kg ha^{-1}, adjusted to 15 % moisture content using Farmex MT-16 grain moisture tester. 1000-seed weight was determined by weighing 1000 seeds per net plot.

Data obtained were subjected to analysis of variance (ANOVA) using the PROC GLM procedure of SAS for Windows Release 9.2 (SAS Institute, 2011). Means were separated using LSD test at 5% level of probability.

RESULTS AND DISCUSSION

Growing condition:

Results showed that the soil of the experimental site had 886 g kg^{-1} sand; 56 g kg^{-1} silt; 58 g kg^{-1} clay. It also contained organic carbon of 14.3 g/kg, total nitrogen content of 1.1 g/kg, available phosphorus of 2.11 mg kg^{-1}, potassium content of 0.21 cmol kg^{-1} and pH (H_2O) of 5.2. The chemical properties of the soil were inherently low in their natural fertility in respect to N, P and K which could not support any meaningful maize yield without fertilization. The climatic condition during the cropping period was adequate for maize production.

Plant height:

Plant height was influenced by N rate ($p=0.0081$) and variety ($p<.0001$). Maize plants grew taller when N was applied at the rates within 30-120 kg N ha^{-1} compared to 0 kg N ha^{-1} (Table 1). This highlights the importance of applied N to maize production. Nitrogen deficiency reduces cell division and growth of plants. Haque et al. (2001) indicated that at sub-optimal level of N, growth is reduced. Mean plant height of the various varieties was in the following order: BR. 9928 DWRSR > TZL COMP.4 C4 > TZEE-Y POP STR. C4 > 2008 DTMA-Y STR (Table 1). These differences may be due to the genetic constitution of the varieties. Study conducted by Bello et al. (2012) reported that most of the late or intermediate varieties evaluated were late to maturity, and higher in plant and ear heights compared to early maturing group. Ewansiha et al. (2020) reported that varietal differences in plant height were real to the point that even in the presence of high N fertilization, the extra-early and early maturing varieties remained shorter than the late maturing varieties. There was no significant interaction between nitrogen rate and maize variety for plant height at different levels of N (Table 1).

Seed weight:
Significant varietal differences occurred in 1000-seed weight (p=0.0092). Mean seed weight of varieties TZEE-Y POP STR. C4, BR. 9928 DWRSR and TZL COMP.4 were heavier than 2008 DTMA-Y STR (Table 1). This may be that, the varieties have better N utilization. The significant nitrogen rate × variety interaction for seed weight (p=0.0186) suggests that the maize varieties varied in their response to levels of applied N for seed weight (Table 1). This was in corroboration with Anjorin (2013) who reported varietal differences in response to varying soil fertility. At 0 kg N ha^{-1}, seed weight differed only between 2008 DTMA-Y STR and BR. 9928 DWRSR as well as between 2008 DTMA-Y STR and TZL COMP.4 C4. At 30 kg N ha^{-1}, differences among the varieties were not significant. At 60 kg N ha^{-1}, differences occurred only between 2008 DTMA-Y STR and BR. 9928 DWRSR. At 90 kg N ha^{-1}, the trend was similar to that obtained at 30 kg N ha^{-1}. At 120 kg N ha^{-1}, differences in seed weight occurred only between BR. 9928 DWRSR and TZL COMP.4 C4. However, 2008 DTMA-Y STR had low seed weight at 0 and 60 kg N ha^{-1}. This may be due to the fact that the variety is early to maturity, had shorter plants and probably have a narrow genetic potential for nutrient utilization for yielding.

Grain yield:
Nitrogen rate (p=0.0006) and variety (p=0.0156) influenced mean grain yield. Grain yield increased with increase in applied N (Table 1). Grain yield was 32, 57, 56 and 61 % higher at 30, 60, 90 and 120 kg N ha^{-1} respectively, compared 0 kg N ha^{-1}. However, grain yield was optimum at 60 kg N ha^{-1} beyond which rate, increase in grain yield was minimal. This means that application of N above 60 kg N ha^{-1} to maize plants may result in fertilizer wastage and soil contamination. Reduced grain yields obtained at 0 and 30 kg N ha^{-1} might have resulted from nutrient insufficiency as little or no N was available. Kamara et al. (2012) reported that N is a major limiting nutrient in the Nigeria Savannas as shown by the significant yield reduction under low N conditions. Ewansiha et al. (2019) suggested that farmers will need to add N to the soil as to improve yields of maize, whether extra-early, early or late maturing varieties. Varieties TZL COMP.4 C4 and BR.9928 DWRSR had comparable grain yields; similarly TZEE-Y POP STR C4 and 2008 DTMA-Y STR had comparable grain yields; but the former had higher yields than the later (Table 1). This may be due to their lateness to maturity and deeper roots to absorb more nutrients. Ewansiha et al. (2019) reported that the late maturing varieties had superior yield compared to the early maturing maize varieties because of better utilization of soil nutrient. There was no significant interaction between nitrogen rate and maize variety for grain yield (Table 1).

CONCLUSIONS
Maize performance was influenced by N rate and variety. Maize plants grew taller when N fertilizer was applied at 30 - 120 kg N ha^{-1} compared to zero N application. Mean grain yield was approximately 2.2, 2.9, 3.5, 3.4 and 3.6 t ha^{-1} at N rate of 0, 30, 60, 90 and 120 kg N ha^{-1}, respectively. Optimum performance was achieved for grain yield at 60 kg N ha^{-1} beyond which rate, additional N did not cause any significant increase in grain yield. Variety BR.9928 DWRSR grew taller than other varieties. Mean seed weight of varieties TZEE-Y POP STR. C4, BR. 9928 DWRSR and TZL COMP.4 were heavier than 2008 DTMA-Y STR. Varieties TZL COMP.4 C4 and BR.9928 DWRSR out-yielded varieties TZEE-Y POP STR C4 and 2008 DTMA-Y STR. Therefore, in the Tropical rainforest agro-ecology, variety TZL COMP.4 C4 and BR.9928 DWRSR should be grown with nitrogen fertilization at 60 kg N ha^{-1} for optimum yield. This will lead to reduction in fertilizer wastage.

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Table 1. Effects of nitrogen rate and variety on plant height, 1000-seed weight and grain yield of maize grown at varying rates of nitrogen fertilization.

Variety (V)	Nitrogen rate (kg N ha^{-1})					
	0	30	60	90	120	Mean
Plant height (cm)						
TZEE-YPOPSTRC4	101.9	130.1	143.0	131.4	132.0	127.7bc
2008DTMA-YSTR	108.5	127.4	125.8	128.6	127.3	123.5c
BR.9928 DWRSR	139.8	152.6	153.3	156.0	145.7	149.5a
TZLCOMP.4C4	121.7	132.0	139.6	135.6	140.0	133.8b
Mean	119.5b	135.5a	140.4a	137.9a	136.2a	
$LSD_{0.05}$ N	12.11					
$LSD_{0.05}$ V	6.15					
$LSD_{0.05}$ N × V	ns					
1000-seed weight (g)						
TZEE-YPOPSTRC4	222.8ab	248.7a	261.6ab	240.0a	241.1ab	242.8a
2008DTMA-YSTR	188.3b	231.7a	210.8b	252.5a	227.3ab	222.1b
BR.9928 DWRSR	242.1a	225.8a	262.7a	242.7a	223.7b	239.4a
TZLCOMP.4C4	255.1a	240.2a	239.6ab	236.4a	277.5a	249.8a
Mean	227.1	236.6	243.7	242.9	242.4	
$LSD_{0.05}$ N	ns					
$LSD_{0.05}$ V	16.24					
$LSD_{0.05}$ N × V	51.35					
Grain yield (kg ha^{-1})						
TZEE-YPOPSTRC4	1619.8	2936.8	3810.3	2878.5	3168.0	2882.7b
2008DTMA-YSTR	1964.2	2740.7	2972.4	3219.1	3411.8	2861.6b
BR.9928 DWRSR	2694.8	2603.4	3263.5	3896.3	3501.0	3191.8ab
TZLCOMP.4C4	2568.2	3412.5	3831.7	3802.0	4191.1	3561.1a

Mean	2211.7c	2923.4b	3469.5ab	3449.0ab	3568.0a
$LSD_{0.05}$ N	586.06				
$LSD_{0.05}$ V	479.49				
$LSD_{0.05}$ N × V	ns				

Means within a column with the same letter(s) are not significantly different at p ≤0.05 using LSD.

ns, not significant

Effect of sawdust on atrazine and nicosulfuron residues in the soil using *Celosia argentea* as a test crop

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ABSTRACT

Atrazine and nicosulfuron are persistent herbicides widely used for weed management in maize. The persistence of these herbicides extends the duration of weed control but may injure associated and follow-up crops of maize. Hence, soil amelioration may be necessary to deter the phytotoxic effect of herbicide residue on these crops. A screenhouse experiment was conducted to investigate the effect of sawdust on atrazine and nicosulfuron residue in the soil using *celosia argentea* as a test crop. A 4 x 5 factorial experiment was laid out in a completely randomised design with four replicates. The first factor comprised four herbicide levels: herbicide-free (control), atrazine at 3.0 kg a.i ha^{-1}, nicosulfuron at 40 g a.i ha^{-1}, and a mixture of atrazine and nicosulfuron at 750 g a.i ha^{-1} and 60g a.i ha^{-1}, respectively. The second factor comprised five levels of sawdust; 0% (control), 5%, 10%, 15%, and 20% by volume in the potting soil. The number of celosia leaves per plant and the plant heights were recorded weekly from 3 weeks after transplanting (WAT) to 6 WAT. The fresh and dry weights of the celosia plants at 6 WAT were also recorded. Findings indicated that residues of the herbicide levels in the soil did not significantly ($P<0.05$) reduce the number of leaves, plant height and fresh weight of celosia. However, nicosulfuron impacted the dry weight of celosia shoots negatively. Sawdust at a low proportion of 5% and 10% improved celosia growth, whereas a 20% proportion reduced celosia growth. The interaction of atrazine and nicosulfuron with 5% sawdust resulted in enhanced growth and yield of celosia over untreated soil. Hence, for the follow-up crops of maize, the addition of 5% sawdust is recommended within the rooting depth of atrazine and nicosulfuron-treated soil.

INTRODUCTION

Atrazine and nicosulfuron are selective herbicides used for weed management in maize production (Akadiri et al., 2017). The persistence of these herbicides in the soil may negatively affect the growth of vegetables cultivated in maize plots in a relay cropping system or as catch crops (Aladesanwa, 2001; Mamnoie, 2021). Increasing the pre-plant interval to avoid reduced vegetable yield in atrazine and nicosulfuron-treated plots may invalidate the fitness of vegetables for the relay cropping system. Hence, it is imperative to alleviate the harmful effect of herbicide residue by reducing its availability to sensitive vegetable crops without significantly disrupting the sowing dates.

Organic matter is an important absorbent for herbicides (Spark & Swift, 2002). Applying soil organic amendments may increase herbicide persistence by increasing the sorption process (Mehdizadeh et al., 2019). However, the sorption of herbicides by organic matter makes them less available for plant uptake (Williams et al., 2001). Celosia (*Celosia* *argentea*) is a commonly cultivated vegetable in Nigeria and has been reported to be sensitive to atrazine and nicosulfuron (Aladesanwa et al., 2001; Mishra et al., 2016). Hence, this study investigated the effect of sawdust on atrazine and nicosulfuron residues using celosia as a bioassay.

MATERIALS AND METHODS

Collection of materials and preparation of potting media

Seeds of *Celosia argentea* (TLV 8) were sourced from the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. The seeds were stored in a paper bag and kept in a dry environment before planting. Topsoil within 0-15cm depth was collected from the Faculty Garden of Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria. The soil was air-dried, sieved with 2mm mesh, and used to fill polythene plant pots measuring 5 cm x 3 cm. In preparing the potting media, ratio-based volume mixing of topsoil and sawdust was adopted. Each sawdust level (0%, 5%, 10%, 15%, and 20%) was used to fill sixteen pots. Hence, eighty filled pots were arranged 1 m apart in the screenhouse. The topsoil used is a sandy clay loam with a neutral pH, 0.96% organic carbon, 1.65% organic matter, 0.08% nitrogen, 3.5 mg kg^{-1} phosphorus, and 0.61 mg kg^{-1} potassium. The soil's sodium, calcium and magnesium contents were determined to be 0.81, 1.4 and 0.7 cmol kg^{-1}, respectively. The sawdust had 94.82% organic carbon, 5.24 mg kg^{-1} phosphorus, and 2.77 mg kg^{-1} potassium. The sawdust's sodium, calcium and magnesium contents were analyzed to be 2.61, 3.21 and 1.86 cmol kg^{-1}, respectively.

Experimental design and treatments

A 4 x 5 factorial experiment in a completely randomised design (CRD) was laid out in a screenhouse at Adekunle Ajasin University, Akungba-Akoko, Nigeria and replicated four times. The first factor comprised four herbicide levels; herbicide-free (control), atrazine at 3.0 kg a.i ha^{-1}, nicosulfuron at 40 g a.i ha^{-1}, and a mixture of atrazine and nicosulfuron at 750g a.i ha^{-1} and 60g a.i ha^{-1}, respectively. The second factor comprised five levels of sawdust in the potting topsoil; 0% (sawdust-free control), 5%, 10%, 15%, and 20%.

Herbicide application in the screenhouse

For per hectare herbicide application proration, four plots measuring 1 m x 1 m each were marked out in the screenhouse. Twenty pots were arranged within each plot such that the five levels of sawdust were replicated four times. Thereafter, different herbicide levels were singly applied to each plot using a knapsack sprayer. Only water was applied to the herbicide-free control.

Transplanting of celosia seedling

Two weeks after sowing (WAS), celosia seedlings at a two-leaf stage were transplanted from the nursery to the potted soil in the screenhouse. The seedlings were transplanted six weeks after herbicide application. The bed was watered thoroughly before transplanting to avoid root damage. Transplanting was done in the morning to reduce water loss through transpiration.

Data collection and analysis

The height and number of leaves of celosia were recorded weekly, starting from 3 weeks after transplanting (WAT) and continued till 6 WAT. Celosia plants were uprooted and analyzed for fresh and dry weight at 6 WAT when the plants had attained commercial maturity. Data obtained were subjected to Analysis of Variance using SPSS version 23 software. The treatment means were separated using Duncan Multiple Range Test at a 5% probability level.

RESULTS

Effect of herbicide residue on growth and yield of celosia

Generally, the number of leaves per plant and height of celosia increased progressively with plant age. There was no significant difference ($P<0.05$) in the number of leaves at the herbicide levels at 3 WAT and 6 WAT, unlike 4 WAT and 5 WAT (Figure 1a). Atrazine had the highest number of leaves per plant at 4 WAT (11 leaves) and 5 WAT (25 leaves). Its number of leaves was significantly ($P<0.05$) higher than herbicide-free control and all herbicide levels at 4 WAT and 5

WAT, respectively. The number of celosia leaves recorded per plant in the herbicide-treated soil was not significantly ($P<0.05$) lower than in the herbicide-free soil throughout the trial.

Celosia plant heights were significantly ($P<0.05$) different across the herbicide levels at 3, 5, and 6 WAT (Figure 1b). At the aforementioned stages in the trial, atrazine had the highest celosia plant height (3.44 cm, 8.78 cm and 14.39 cm) and its celosia plant heights were significantly higher than the herbicide-free control (2.47 cm, 6.09 cm and 9.82 cm) which had the least.

There were no significant differences ($P<0.05$) in the fresh weights of celosia among the herbicide levels at 6 WAT (Figure 1c). Hence, the effect of herbicide residue on the fresh weight of celosia was insignificant. Celosia plants in potted soil treated with atrazine had the highest fresh weight of shoot (11.4 g) and root (2 g), while nicosulfuron had the least (5.6 g and 1 g, respectively). The dry weights of celosia shoot and root were significantly different ($P<0.05$) at 6 WAT (Figure 1d). Celosia plants in herbicide-free control had the highest dry weight of celosia shoot and root (1.05 g and 0.35 g). Herbicide-free control had a significantly higher weight of celosia shoot and root than nicosulfuron (0.42 g and 0.18g), which had the least. The dry shoot and root weight of celosia in nicosulfuron-treated soil were significantly reduced ($P<0.05$) compared to herbicide-free control. However, the atrazine-nicosulfuron mixture and atrazine had comparable celosia dry weights with the herbicide-free control.

Effect of sawdust on growth and yield of celosia

The number of leaves and plant height of celosia were significantly different ($P<0.05$) among the sawdust levels from 3 WAT to 6 WAT (Figure 2a&b). Throughout the trial, the highest number of celosia leaves (8, 14, 31, and 49 leaves) were recorded from 5% sawdust. Contrarily, 20% sawdust had the least number of celosia leaves (4, 5, 7 and 14 leaves), and it was significantly ($P<0.05$) lesser than 5% sawdust throughout the trial. Notably, 20% sawdust resulted in a significantly ($P<0.05$) reduced number of leaves at 3 WAT and 4 WAT compared to sawdust-free control (0% sawdust). However, it had a comparable number of celosia leaves per plant with sawdust-free control at 5 WAT and 6 WAT. Judging by the sawdust-free control, the 10% sawdust and 15% sawdust resulted in a significantly increased and a comparable number of celosia leaves, respectively.

Similarly, weekly results from 3 WAT to 5 WAT showed that 5% sawdust had the highest celosia plant height (4.09 cm, 6.94 cm, 10.77 cm and 17.71 cm). It was significantly ($P<0.05$) different from 20% sawdust which had the least plant height. The 5% sawdust and 10% sawdust resulted in celosia plant height significantly higher than the sawdust-free control (0% sawdust), whereas 15% sawdust and 20% sawdust resulted in a comparable plant height and a significantly reduced ($P<0.05$) celosia plant height, respectively.

The fresh and dry weights of celosia across the sawdust levels were significantly different at 6 WAT (Figure 2c&d). The 5% sawdust had the highest shoot, root and total fresh weight (15.94 g, 3.06 g and 19 g), whereas the lowest shoot, root, and total fresh weights were recorded in 20% sawdust (1.94 g, 0.06 g and 2 g). The shoot, root and total fresh weights that resulted from 5% sawdust were significantly higher than the sawdust-free control, whereas 10%, 15% and 20% sawdust had a comparable shoot, root, and total fresh weight. The dry weight of the celosia plant followed the same trend as the fresh weight across the sawdust levels.

Interaction of herbicide residue and sawdust on growth and yield of celosia

The number of celosia leaves differed significantly ($P<0.05$) among the herbicide and sawdust interactions. (Table 1). Based on weekly results, atrazine and 5% sawdust (A+S5%) recorded the highest number of celosia leaves from 3 WAT to 6 WAT (9, 21, 47, and 64 leaves). In contrast, atrazine and 20% sawdust (A+S20%) had the lowest number of celosia leaves at 3 WAT and 4 WAT (3 and 5 leaves). The interaction of nicosulfuron and 20% sawdust (M+S20%) resulted in the lowest number of celosia leaves at 5 and 6 WAT (7 and 11 leaves). Remarkably, the number of celosia leaves from atrazine and 5% sawdust (A+S5%) interaction was significantly higher (P<0.05) than in untreated soil (C+S0%) and herbicide-free soil with 5% sawdust (C+S5%). Also, untreated soil (C+S0%) had a comparable number of celosia leaves with all other interactions, except for the significantly increased number of celosia leaves at 4 WAT and 5 WAT by nicosulfuron and 5% sawdust (N+S5%) and interaction of atrazine and 10% sawdust (A+S10%) at 5 WAT.

The plant height of celosia differed significantly (P<0.05) with respect to herbicide and sawdust interaction. The interactions of atrazine and 5% sawdust (A+S5%) and nicosulfuron and 5% sawdust (A+S5%) had the highest celosia plant height at 3 WAT (5.25 cm) and 6 WAT (22.85 cm). Also, atrazine and 5% sawdust (A+S5%) resulted in the highest celosia plant height at 4 WAT (9.18 cm) and 5 WAT (14 cm). Notably, throughout the study, atrazine and 5% sawdust (A+S5%) had a significantly higher height of celosia plants than untreated soil (C+S0%). A similar trend was also found in nicosulfuron and 5% sawdust (N+S5%). None of the interactions had significantly (P<0.05) reduced celosia plant height compared to the untreated soil (C+S0%).

The fresh and dry weight of celosia per plant differed significantly (P<0.05) among the interactions of herbicide and sawdust. Atrazine and 5% sawdust (A+S5%) had the highest fresh shoot, root and total weight (26.75g, 5g and 31.75g) among the interactions. The least fresh shoot, root and total weights (1.25g, 0.10g and 1.35g) were found in nicosulfuron and 20% sawdust. However, the least fresh shoot, root and total weights were comparable with untreated soil (3.50g, 0.75g and 4.25g).

Herbicide-free and 5% sawdust (A+S5%) had the highest dry shoot, root and total weights of celosia (2.97g, 1.06g and 4.03g) among the interactions. The interaction of nicosulfuron and 20% sawdust had the least dry shoot, root and total weight of celosia (0.08g, 0.02g and 10c), and it was comparable with the untreated soil (C+S0%).

DISCUSSION

This study showed that celosia could be transplanted into atrazine-treated soil six weeks after treatment without a decrease in yield. The transient increase observed in the growth parameters of celosia plants in atrazine-treated soil might have resulted from the hormetic effect (low dose stimulation and high dose inhibition of growth) of atrazine residue. Lytle & Lytle (2005) observed stimulatory growth in *Sesbania vesicaria* and *Vigna luteola* exposed to low concentrations of atrazine. The absence of atrazine phytotoxicity in this study might have resulted from the mitigated concentration of atrazine through decomposition and sorption. Atrazine catabolism and sorption by soil components reduce the concentration of atrazine in the soil, thus causing the stimulatory effect at a low concentration.

The reduced dry weight of celosia in nicosulfuron-treated soil was probably due to the phytotoxicity of nicosulfuron residue. Rahman et al. (2011) reported that nicosulfuron residue reduced the dry weight of mustard plant (*Sinapis alba*), unlike atrazine applied on the same day. The use of herbicide mixture for weed management is justified in this study as soil residue of atrazine and nicosulfuron mixture was not phytotoxic to celosia even at a higher concentration of nicosulfuron, which solely reduced celosia dry weight.

For a longer duration of this trial, the improved growth of celosia in soil treated with 5% and 10% sawdust was probably due to the ability of sawdust to decrease the soil bulk density and increase the soil organic carbon content. The decrease in celosia growth caused by 20% sawdust could be attributed to nitrogen immobilization commonly associated with soil amendments with a high carbon-to-nitrogen ratio (Iroegbu et al., 2020). This study corroborates the findings of Siddiqui & Alam (1990) that sawdust as soil amendment improves the growth of plants.

The comparable growth of celosia in atrazine-treated soil without sawdust and untreated soil disagrees with Aladesanwa et al. (2001), who reported reduced growth of celosia sown within twelve weeks pre-plant interval on atrazine-treated soil. It is opined that the difference in the soil textural class used for this study may be responsible for this different outcome. Further studies on the role of the higher clay content in the soil may provide more helpful information. The improved growth of celosia resulting from the interaction of atrazine and nicosulfuron with 5% sawdust over the interaction of herbicide-free and 5% sawdust indicates the synergistic effect of 5% sawdust and residues of atrazine and nicosulfuron.

CONCLUSION

The soil residues of atrazine and atrazine-nicosulfuron mixture are not injurious to celosia transplanted at a pre-plant application interval of six weeks. Using a mixture of atrazine and nicosulfuron for weed management in maize mitigates the phototoxic effect of sole nicosulfuron residue on follow-up celosia. Applying 5% sawdust to atrazine and nicosulfuron-treated soil improves celosia growth.

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Figure 1: Effect of herbicide residue on growth and yield of celosia

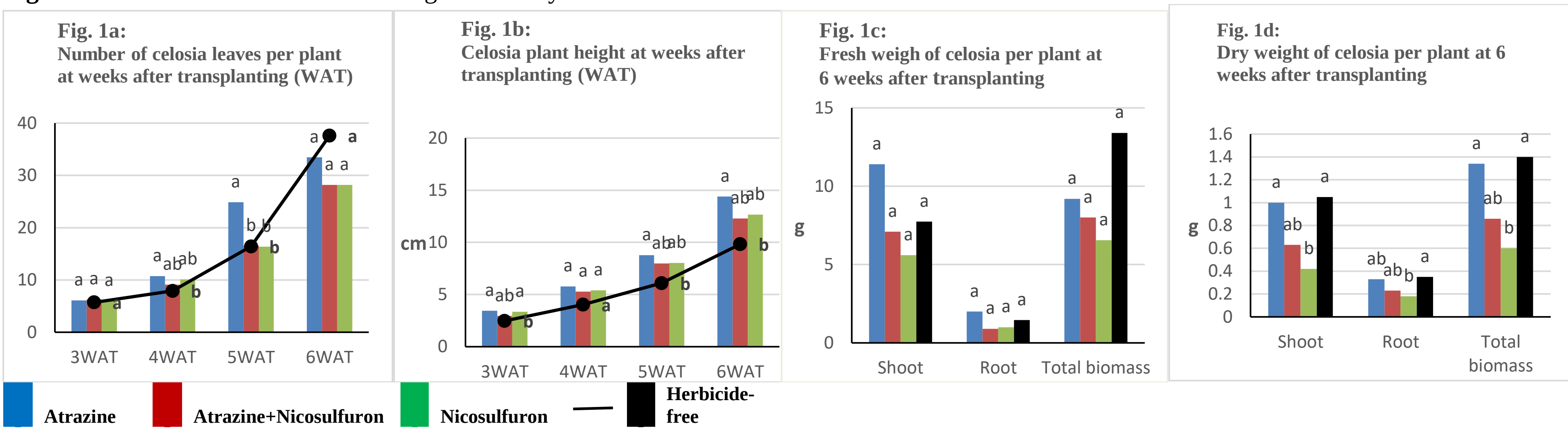


Figure 2: Effect of sawdust on growth and yield of celosia

Fig. 2a:
Number of celosia leaves per plant at weeks after transplanting (WAT)

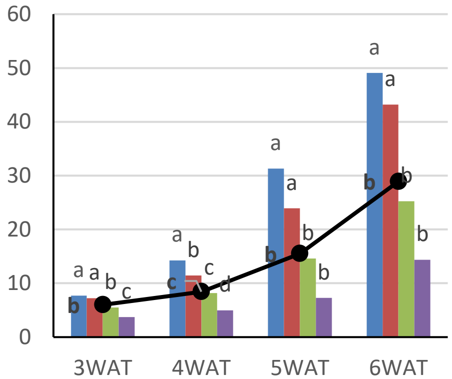


Fig. 2b:
Celosia plant height at weeks after transplanting (WAT)

Fig. 2c:
Fresh weight of celosia per plant at 6 weeks after transplanting

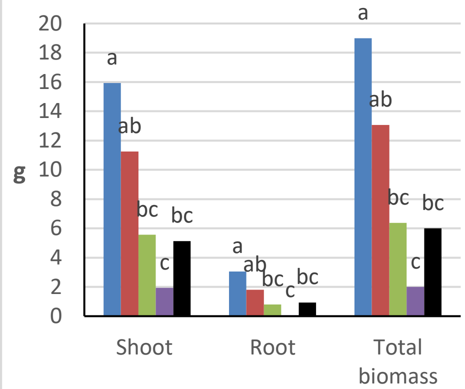
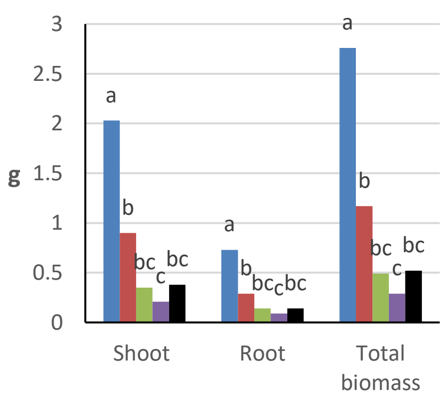


Fig 2d:
Dry weight of celosia per plant at 6 weeks after transplanting



5% Sawdust **10% Sawdust** **15% Sawdust** **20% Sawdust** **Sawdust-free**

Table 1: Interaction effect of herbicide and sawdust on growth and yield of celosia

Treatment	Number of leaves (plant^{-1})				Plant height (cm)				Fresh weight @ 6WAT (g/plant)		
	3WAT	4WAT	5WAT	6WAT	3WAT	4WAT	5WAT	6WAT	Shoot	Root	Total
A + S0	4.75d-g	7.25c-e	16.50b-d	24.75b-d	3.00b-f	4.95c-g	7.13b-e	11.13c-f	5.25bc	0.50bc	5.75bc
A + S5	9.00a	21.00a	46.75a	64.00a	5.25a	9.18a	14.00a	22.85a	26.75a	5.00a	31.75a
A + S10	7.00a-e	12.00c	32.50ab	49.75a-e	4.10ab	6.78a-c	10.95ab	19.18a-c	13.50a-c	2.25a-c	16.00a-c
A + S15	6.50a-f	9.00c-e	21.00b-d	33.00a-e	3.65a-c	5.38c-g	8.25b-e	13.50b-f	9.50bc	1.75bc	11.25bc
A + S20	3.25g	4.50e	7.75d	16.50c-e	1.20f	2.68fg	3.58e	5.80f	2.00c	0.25bc	2.25c
M + S0	8.25a-c	11.50c	23.00b-d	42.75a-e	3.55a-d	6.33a-d	9.20a-d	14.75a-f	9.00bc	1.25bc	10.25bc
M + S5	7.00a-e	10.50cd	25.25b-d	42.75a-e	3.23b-e	5.70b-f	9.45a-c	16.00a-d	14.75a-c	3.00a-c	17.75a-c
M + S10	7.25a-d	10.50cd	16.25b-d	28.25b-e	3.93ab	6.88a-c	9.75a-c	14.00a-f	6.50bc	0.25bc	6.75bc
M + S15	5.00d-g	7.75c-e	11.25cd	27.75b-e	2.45b-f	4.58c-g	7.33b-e	10.63c-f	3.50bc	0.30bc	3.5bc
M + S20	4.00fg	5.25de	7.00d	13.25de	1.60d-f	2.93e-g	4.15de	6.08ef	1.75c	0.32bc	2.07c
N + S0	5.50c-g	7.50c-e	11.25cd	19.75c-e	3.25b-e	4.75c-g	5.63c-e	7.95d-f	2.75bc	1.05bc	3.75bc
N + S5	5.50c-g	17.50ab	32.50ab	45.25a-d	5.25a	8.58ab	13.75a	22.85a	11.50bc	2.00a-c	13.50bc
N + S10	7.50a-d	12.75bc	17.50b-d	28.25b-e	4.3ab	6.50a-c	10.25a-c	15.38a-e	7.75bc	1.00bc	8.75bc
N + S15	5.00d-g	8.00c-e	14.00b-d	27.75b-e	2.60b-f	4.75c-g	6.43b-e	11.75c-f	4.50bc	0.75bc	5.50bc
N + S20	3.50g	4.75e	6.50d	10.50e	1.28ef	2.55g	4.15de	5.33f	1.25c	0.10c	1.35c
C + S0	**5.50c-g**	**7.50c-e**	**11.25cd**	**25.25b-e**	**2.93b-f**	**4.01c-g**	**`5.95b-e**	**9.20d-f**	**3.50bc**	**0.75bc**	**4.25bc**
C + S5	6.00b-g	8.00c-e	20.75b-d	44.25a-e	2.63b-f	4.38c-g	5.88b-e	9.65d-f	10.75bc	2.25a-c	13.00bc
C + S10	7.25a-d	10.50cd	29.75a-c	57.00ab	3.65a-c	5.88b-e	9.13a-d	15.55a-d	17.25ab	3.50ab	20.75ab
C + S15	5.50c-g	8.00c-e	12.25cd	23.50b-e	1.88c-f	3.38d-g	5.45c-e	8.80d-f	4.50bc	0.75bc	5.25bc
C + S20	4.25e-g	5.50de	8.00d	17.25c-e	1.28ef	2.53g	4.15de	5.88f	2.75bc	0.25bc	3.00bc

Means in a column followed by the same letter are not significantly different according to DMRT (P = 0.05). A=Atrazine, M=Atrazine + Nicosulfuron, C=Herbicide-free soil, S5% = 5% sawdust, S10% = 10% sawdust, S15% = 15% sawdust, S20% = 20% sawdust, C+S0 = Untreated soil

Pedological Characterization and Classification of Some Soils Under Different Land Uses at Igboora Area, Oyo State, Nigeria.

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ABSTRACT
Little or no information on pedological characterization and classification of soil developed over Igboora is known. The objective of this study is to provide invaluable information on how pedogenic processes along the different land use affect the soil properties, aim to gauge the soil potential. Difference in soil properties in five land uses (cassava, maize, maize inter-planted with cassava, fallow and orchard) were observed on many soil properties as they influence crop growth. Soil profiles with varies depths in centimetres were described and sampled horizon-wisely for morphological, physical and chemical analysis. The results of laboratory analysis revealed that the soil reaction is strongly acidic. The soil organic carbon, total nitrogen, available phosphorous showed increasing trend with depths of pedons along the land uses, this suggested that these soil properties were affected by the land uses. There are existence of two different soil order (ultisol and inceptisol). Farmers in the study area were advised not only required to adopt integrated soil fertility management but also embrace soil conservation measures to maintain soil physio-chemical properties.

Key words: Pedological, interplanted with, morphological and chemical characteristics.

INTRODUCTION
Climate and geological history are important factors affecting soil properties on regional and continental scales. Also, land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc. (Liu *et al*, 2010). Land use may change the processes of transport and distributions of nutrients.

In non-cultivated land, the type of vegetative cover is a factor influencing the soil organic carbon content. In addition, soils through land use change also caused considerable alterations and resulted in soil quality diminishes after the cultivation of previously tilthed soils (Neris *et al*, 2012). Thus land use and types of vegetation must be taken into account when relating soil nutrients with environmental conditions (Liu *et al*, 2010).

The capacity of soil to function may be determined by measuring soil physical and chemical properties (Buol *et al*, 2011), majority of soil properties were vulnerable to degradation as a result of poor land use management practices.

To come out with sound and reliable information about the soil in relation to land uses pedological classification is the best option. Pedological classification is gathering of vital information on soil by systematic identification, grouping and delineation of different soils in the locality (Kebency *et al*, 2015; Mswanya *et al*, 2016).

Pedological characterization provides valuable information and knowledge on soil characteristics and gives clear understanding on soil genesis, morphology, classification and spatial distribution of soil in an area as observed by Karuma *et al.*, 2015; Kabenay *et al.*, 2015. The information gathered through pedological characterization is needed by soil fertility experts to carry out fertilizer trial and establish meaningful fertilizer recommendations (Msanya *et al.*, 2003). Crop production in Igboora are still being carried out through deforestation on steep slopes, marginal lands and fragile soil with inadequate investment in soil conversation measures which also aggravates soil erosion. The farming system is traditional; modern agricultural technology is not applied in most part of Igboora. As a result, many agricultural soils in igboora have reached a critical point. The situation of the study area is worse and the soil resources have degraded at alarming rate due to continuous cropping. With these practices, the sustainability of agriculture and the livelihood of the community are under severe threat. To come up with sound management practices, investigating the impacts of the interaction of these factors is imperative. This study, therefore, was carried out at the Oyo State College of Agriculture and Technology (OYSCATECH) Teaching and Research Farm and its surrounding farms in igboora area with the objective to characterize and classify the soils of the area in terms of their morphological, physical and chemical properties in order to generate needed information for land use planning.

MATERIALS AND METHODS

The study area is approximately 120 hectares of land located between Igboora and Jakata village in Ibarapa central Local Government area of Oyo state, Nigeria. It is defined within longitudes of $3^0\ 57^1$, 10^1 and $3^o\ 59^1$ E and latitudes 7^o, 15^1 and 7^o, 33^1 of the equator. Base on physiographic, climatic and vegetation characteristics, soil morphological, physical and chemical properties were observed at 0-20, 20-35, 35-65, 65-95 and 95-125cm depth with the aid of Dutch auger for identified, characterization and classification. Five selected units and their respective soil profiles are: pedon-1 (cassava plot), pedon-2 (maize plot), pedon-3 (maize interplanted with cassava), pedon-4 (fallow) and pedon-5 (orchard).

The soil samples were air dried, crushed and passed through 2.0 mm sieve. Particle size analysis was conducted using the modified Bouyoucous hydrometer method. Soil p^H was determined in two solutions, using the follow procedure p^H in water and potassium chloride. The soil were also classified using key to soil taxonomy (soil survey Staff 2006).

RESULT AND DISCUSSION

Morphological properties

The soil morphological characteristics of the studied pedons were shown in Table 1. Distinct horizons layers and argellic–B horizons were observed in the pedons expect for the orchard area that had Bw horizon. Four of the pedons, cassava, maize, maize ipw cassava and fallow had Ap, B and Bt horizons, whereas the pedons at orchard had Ah, Bw and Bhs horizons sequences. Depth and horizons of the profiles were highly variable along the five pedons. Pedon-2 and 3 were characterized by truncated surface layer (20/18 cm), whereas pedon-1 have a moderate shallow depth at B_2 to Bt_2. Contrast, relatively shallower solum and fewer amounts of coarser materials in pedon-3 suggesting that the rate of weathering process were increased with humans activities such as prolong intensive tillage. Surface soil colour (moist) range from light brown (7.5YR$^3/_3$) to commons medium faint light brown (7.5 YR$^5/_2$) lime mattles and lime coating Table 1. Variation in soil colour is due to organic matter which tends to coat minerals particles, darkening and masking the brighter colours of the minerals themselves, and water content which affect the oxidation state of iron and manganese, Munishi,. (2010). Soil structure of the surface horizons of pedons was generally crumb with some variation in size of peds.

Physical Properties

The soil of the different land use at 0 – 20cm horizons were found to be almost the same with loamy sand expect for that of orchard field with silt loam Table 1. The individual soil properties considered silt and sand contents were the most highly correlated with erodibility.

Chemical Properties

The chemical properties of studied pedons were presented in table 1

Topsoil of cultivated field was rated as moderately acidic to slightly acidic whereas uncultivated was rated as acidic to medium acidic. Topsoil organic carbon contents of the studied pedons were higher in the fallow and orchard but lower in the cultivated land.

Total nitrogen followed the trend of organic carbon. An increase in available phosphorous content in the orchard field followed by fallow land could as a result of relative higher organic matter content present in Ap horizons, which strongly associate with organic carbon.

Table 1: Main morphological, physical and chemical features of the studied soil profiles in Igboora

Depth (cm)	Horizon	Colour		Structure[1]	Particle size analysis%			pH	OC	TN	Av.P
		Dry	Moist		sand	Silt	Clay		(%)	(%)	mg kg^{-1}
Pedon-1: Cassava plot											
0-20	Ap	7.5YR 5/8	7.5YR 5/2	Cr Cs	70	20	10	6.0	0.85	0.09	11.8
20-35	B	7.5YR 5/8	7.5YR 5/2	Cr Cs	48	26	26	5.5	0.88	0.09	7.2
35-65	B^1	2.5YR 4/8	7.5YR 54	Cr Cs	52	26	22	5.2	0.85	0.09	8.3
65-95	B^2	10YR 5/1	5YR 6/4	Gr Cs	54	26	20	5.4	0.41	0.04	5.0
95-125	Bt^2	10YR 5/2	2.5YR 8/1	Ag B1	58	24	18	5.3	0.95	0.11	6.0
Pedon-2: Maize plot											
0-20	A^p	7.5YR 2/2	7.5YR 5/2	Cr Cs	70	20	10	6.0	0.75	0.21	12.0
20-35	B	7.5YR 3/3	7.5YR 5/2	Cr Cs	56	14	30	5.5	0.82	0.09	12.0
35-65	B^1	2.5YR 5/9	7.5YR 5/4	Cr Cs	59	24	17	5.2	0.54	0.06	3.1
65-95	B^2	10YR 5/2	5YR 6/4	Gr Cs	64	20	16	5.4	0.62	0.14	11.0
95-125	Bt^2	10YR 5/2	2.5YR 8/1	AgB1	60	20	20	5.3	0.44	0.05	5.8
Pedon-3: Maize ipw cassava											
0-29	A^p	7.5YR 3/6	7.5YR 3/3	Gr Cs	71	10	19	5.1	0.68	0.18	10.2
29-40	B	7.5YR 4/6	7.5 YR3/4	Cr	57	15	28	5.2	0.48	0.05	2.3
40-80	B^1	2.5YR 5/7	10YR6/6	Cr	50	20	30	5.0	0.34	0.04	4.1
80-140	B^2	10YR 3/6	10YR 5/8	Ag B1	50	25	25	5.5	0.17	0.02	4.4
140-180	Bt^2	10YR 4/6	2.5YR 6/6	Pr	49	30	21	5.3	0.51	0.05	7.0
Pedon-4: fallow land											
0-29	A^p	7.5YR5/9	7.5YR3/4	Gr Cs	63	21	10	6.4	2.35	0.24	25.0
29-40	B	7.5YR5/6	7.5YR4/3	Ag B1	46	26	28	5.7	0.82	0.09	9.7
40-80	B^1	7.5YR5/7	5YR5/3	Cs	30	40	30	5.7	0.54	0.06	6.0
80-140	B^w	10YR2/3	5YR7/6	Co Md	39	31	33	6.0	0.82	0.08	10.2
140-180	B^t_2	10YR5/2	5YR7.6	Co Md	36	31	33	6.0	0.78	0.08	7.0
Pedon-5: Orchard											
0-29	Ah	2.5YR4/8	7.5YR3/4	Cr	40	50	10	6.8	2.28	0.29	27.0
29-40	B	2.5YR5/3	7.5YR5/3	Cr	58	32	10	6.6	1.31	0.12	8.5
40-80	B_t	7.5YR	5YR6/8	Cr	41	21	38	6.4	1.7	0.18	7.0
80-140	Bw	10YR2/3	5YR6/8	Cr	42	23	35	6.5	1.26	0.13	28.0
140-180	Bhs	10YR	5YR6/6	Pr	44	22	34	6.2	1.16	0.12	28.0

[1]Structure: Cr Cs= crumb coarse; Ag B1 =angular blocky medium; Gr Cs = angular coarse; Ag = angular Prn= prismatic
OC = Organic Carbon;.TN = Total Nitrogen AV.p = Available Phrosphorus.

Classification

Field description and laboratory analytical data were used to classify the soils of the stury area according to the United States Department of Agriculture (USDA) soil taxonomy and the world reference base for soil resources. The soils units with ultic properties in the topsoil (A horizon) and argillic – B horizon were classified as ultisol. Long time cultivation and erosion cause the destruction of this dark topsoil in some of the ultisol profiles (pedon – 1, 2, 3 and 4). Pedon 5 that had inceptic properties in the subsurface (Bt horizon) was classified as inceptisol. Pedon – 1, 2, 3 and 4 was further classified at great group (kandiultisol), subgroup (Typic kandiultisol).

CONCLUSION

The low values and high chromas of some colour observed in cultivated land are indicative of low organic matter contents. At the surface horizons, they suggest loss of humified organic matter content mostly through surface wash as organo-mineral complexes of the clay-size fraction. The particle-size data show silt depth functions that reflect parent material origin. The physical and the chemical properties of the soil of the study area indicate that of chemical weathering and, therefore mineralogical alteration have proceeded translocation. The slightly acidity observed in pedons attest to the influence of pre-weathered parent materials on the chemical properties of some soil within the tropics. It is possible that the land used pattern affects morphological, physical and chemical status of soil in the study area. Therefore, their placement in classification systems using soil Taxonomy were made easy. '

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Sub-Theme C: Animal production, Nutrition, Health, Genetic improvement and welfare and Fisheries and aquaculture production, nutrition, genetic improvement and postharvest technology
(Cont'd)

Response of Broiler Chickens Exposed to Heat Stress, and fed with Dietary Inclusion of *Bambusa Vulgaris* Leaf Meal

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ABSTRACT
A fifty-six (56) days study was conducted to determine the effect of varying levels of *Bambusa vulgaris* leaf meal (BLM) inclusion in the diets of broiler chickens exposed to heat stress. A total of one hundred and fifty Arbor Acres broilers were allotted randomly into five (5) dietary treatments (T1-T5) of thirty per treatment and ten per replicate. T1, T2, T3, and T4 were fed 0%, 1%, 1.5%, and 2% BLM included diets respectively, while T5wase fed 200g/mg of Vitamin C included diet. The experimental birds were exposed to a temperature of 50±1°C between the hours of 12-4pm daily for four weeks. Data collected on growth performance, and stress indicators were subjected to one way analysis of variance. The result showed that birds on T4 had the highest ($p<0.05$) feed intake (267g), body weight gain (1504g), and the best FCR (3.64). The serum corticosterone (3.4865U/ml) and glutathione peroxidase (230.3U/ml) levels decreased with an increase in BLM inclusion in the diet with birds on T4 having the lowest ($p<0.05$) values. However, malondialdehyde and superoxide dismutase values increased with an increase in BLM inclusion in the diets with birds on T4 having the highest values (1.7618nmol/ml and 1865.7U/ml respectively). In conclusion, *Bambusa vulgaris* leaf meal inclusion up to 2% in the broiler diet could ameliorate heat stress conditions and improved broiler chicken performance.
Keywords: Heat stress, Broiler chicken, Bamboo leaf, Stress indicators, Serum

INTRODUCTION
Among poultry meats, broiler chickens have assumed great global recognition (Seifi *et al*., 2018) because the production cycle is short and the meat is universally acceptable with little or no restrictions. Over the decades, genetic tools have been used to develop broiler chickens to meet demands (Athrey, 2020) however, heat stress especially in the tropics has constrained the effectiveness and efficiency of broiler chicken production (Sugiharto *et al*., 2017a). Heat stress is a physiological state whereby an animal is subjected to temperatures that are higher than 30 ^{0}C (Seifi *et al*., 2018) resulting in concurrent physiological difficulties, poor growth, the spread of diseases, and death (Sugiharto *et al*., 2017b). Authors have used plant materials like *Moringa oleifera* (Mona *et al.* 2017), bamboo, pawpaw, and

neem leaf (Oloruntola *et al.* 2018) as a dietary supplement, antioxidant or as a feed additive in broiler chicken production.
The bamboo plant found in many parts of the world, and used culinary and medicinal purposes for long, contains antioxidants and free radical scavenging properties (Shen *et al.*, 2019). Research has shown that *bamboo* leaf contains polysaccharides, polyphenols, and flavonoids, these active ingredients contain anti-inflammatory and antioxidant properties which could lower lipids, thereby reducing heat stress both in animals and in humans (Yu *et al.*, 2019). Little research has been carried out on the use of bamboo leaf meals to alleviate heat stress in broiler chickens, therefore, this study investigated the use of bamboo leaf meal as a feed additive in combating heat stress in broiler chickens.

MATERIALS AND METHOD

The experiment was carried out at the poultry unit of the Teaching and Research Farm of Landmark University, Omu-Aran Kwara state, Nigeria. A total of one hundred and fifty (150) day old unsexed broiler chickens were distributed, using a completely randomized design (CRD), into five treatments of 3 replicates each. The birds were kept in an electrical heated pen house on deep litter with wood shavings as litter material, they were given standard vaccinations and medications. The birds were fed with broiler starter diets for three weeks after which they were fed the experimental broiler finisher diets from week four to week eight. Birds were exposed to excess heat between 12pm-4pm at 50 ± 1^0C on days 29-56. Thermometers were provided in each pen to measure the heat generated. All experimental birds were placed under the same environmental condition. Bamboo leaf meal (BLM) was included into the broiler finisher diets at 0%, 1.0%, 1.5% and 2.0% inclusion levels for birds in treatments 1, 2, 3 and 4, respectively, while the broiler finisher diet for birds in treatment 5 contained 0.2% (200mg/kg) vitamin C and fed to the birds **as** shown in Table 1.
The proximate analysis of broiler diets was conducted using the AOAC procedure (AOAC, 2005), photochemical screening: alkaloids, phytate, flavonoid, saponin, and tannin were carried out by standard procedure of Kokate, (1994). All chemical analyses were done in triplicates. On day 56, blood sampling was performed by randomly selecting two birds per replicate. The collection of blood samples was achieved through the brachial veins of the birds. Superoxide dismutase (SOD), serum glutathione peroxidase (GPx), corticosterone (CORT), and malondialdehyde (MDA) were determined using the method described by Akhavan-Salamat *et al.*, (2015).
The means of the samples were compared using analysis of variance (ANOVA), with the level of significant difference set at (p-0.05). The Duncan multiple range test was used to separate the means and the SAS program was used to conduct this analysis (version 9.4)

Table 1: COMPOSITION OF EXPERIMENTAL DIETS (DM%)

Ingredients (%)	0.00% BLM (T1)	1.00% BLM (T2)	1.50% BLM (T3)	2.00% BLM (T4)	0.20% Vit.C (T5)
Maize	64.70	63.70	63.70	63.70	64.50
Soya bean meal	30.00	30.00	29.50	29.00	30.00
Fish meal	1.50	1.50	1.50	1.50	1.50
Bone meal	3.00	3.00	3.00	3.00	3.00
Bambusa vulgaris	0.00	1.00	1.50	2.00	-
Vitamic C	-	-	-	-	0.20
[1]Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100

[1]Contain the following: vit A 10,000IU, vit D_3 1500 IU; vit E 10,000mg, vit k_3, 1500mg, vit B_1 1600mg, vit B_2 4000mg, pentothenic acid 10mg; nicotinic acid 2.5mg chlorine 3.5mg; folic acid 1mg; magnesium 56mg; lysine 1mg; iron 20mg; zinc 50mg; cobalt 1.25mg, biotin 7.5mg copper 30mg, manganese 40mg, selenium 2mg antioxidant 1250mg.

RESULTS

The proximate composition and phytochemicals of the experimental diets is shown in Table 2. The result indicates that the CP, CF and ash values of Diets T4 (187.21g, 375.50, and 110.01g respectively) were higher ($p<0.05$) than CP, CF and ash values for the other diet while the lowest ($p<0.05$) CP (135.01g), CF (261.55g) and ash (105.20g) values were recorded for diet T1, T5 and T5 respectively. The CP, CF and ash levels were noted to increase with increase in the BLM inclusion level in the diet. The phytochemical results showed the phytate, flavonoids, tannin, and saponin values increased with the increased addition of BLM in the diets. Flavonoids contents were similar and higher ($p>0.05$) for diets T4 and T5, whereas it is low ($p>0.05$) for T1 compared with the other diets.

The growth performance of broiler chickens fed BLM at different inclusion levels in the diet is shown in Table 3. The feed intake and weight gains of the birds increased as BLM increased in the diet, however, it was observed birds fed diet 1 had the lowest ($p<0.05$) feed intake and weight gain compared to birds fed the other diets while birds fed diet 4 had the highest ($p<0.05$) values for these parameters. The FCR values were comparable ($p>0.05$) for birds fed diets1, 4, and 5 with the best FCR from birds on diet 4.

Table 4 indicated that there was no significant difference ($P>0.05$) between glutathione peroxidases (GPx), corticosterone (CORT), and malondialdehyde (MDA) in all the diets. However, the range of glutathione peroxidase and malondialdehyde reported in this study is high (226.5-419.6U/ml and 1.2854-1.7618nmol/ml respectively). The superoxide dismutase is higher in diet 1 with 0% BLM (4477.6 U/ml) and diet 5 with 0.20% vitamin C (8955.2 U/ml) compared with other diets with BLM inclusion (1492.5, 1726.4, and 1865.7 U/ml), but much higher in diet 5.

Table 2: Proximate and phytochemicals composition (g/kg DM) of the diets

Proximate	0.00% BLM (T1)	1.00% BLM (T2)	1.50% BLM (T3)	2.00% BLM (T4)	0.20% Vit.C (T5)	P value	SEM
Crude protein	135.01^{c}	137.80^{c}	157.20^{b}	187.21^{a}	160.02^{a}	0.0122	5.72
Crude fibre	350.04^{b}	355.00^{b}	360.01^{a}	375.50^{a}	261.55^{c}	0.0220	4.95
Ether extract	79.82^{a}	79.80^{b}	80.70^{a}	82.80^{a}	91.05^{a}	0.0170	1.88
Ash	105.20^{c}	107.57^{b}	109.57^{a}	110.01^{a}	107.24^{b}	0.0203	1.76
Phytochemical							
Phytate	39.93^{c}	40.22^{b}	42.99^{a}	43.02^{a}	40.11^{b}	0.0081	4.00
Flavonoids	50.99^{c}	70.64^{b}	72.85^{b}	74.90^{a}	75.10^{a}	0.0254	2.32
Saponin	20.90^{c}	21.82^{c}	38.95^{a}	39.31^{a}	36.05^{b}	0.0040	3.92
Tannin	0.15^{c}	1.20^{b}	4.30^{a}	4.32^{a}	0.99^{b}	0.0045	0.17

Table 3: Growth Performance of broiler chickens fed with experimental diets

Parameters	0.00% BLM (T1)	1.00% BLM (T2)	1.50% BLM (T3)	2.00% BLM (T4)	0.20% Vit.C (T5)	p-value	SEM
Initial weight (g)	630.00	623.33	633.33	622.22	620.00	0.7136	1.22
Final weight (g)	1714.17^{c}	1882.04^{bc}	1999.26^{ab}	2125.23^{a}	2087.04^{a}	0.0040	3.39
D/weight gain (g)	51.943^{c}	59.463^{bc}	65.203^{b}	71.573^{a}	69.857^{a}	0.0027	1.58
T/weight gain (g)	1074.17^{c}	1248.71^{bc}	1355.93^{ab}	1503.01^{a}	1457.04^{a}	0.0027	3.32
Av. feed intake (g)	235.02^{b}	255.99^{a}	259.25^{a}	266.66^{a}	260.93^{a}	0.0007	0.82
FCR (%)	3.95^{b}	4.54^{a}	4.50^{a}	3.64^{b}	3.74^{b}	0.0046	0.18
Mortality (%)	0.93	1.97	0.93	2.09	2.78	0.7485	0.48

Means with different superscripts (a, b and c) are significantly different ($p< 0.05$) across the rows, SEM= Standard error of mean. Dwt gain = Daily weight gain, FCR= Feed conversion ratio.

Table 4: Stress indicators levels of broiler chickens fed with experimental diets

Parameters	0.00% BLM (T1)	1.00% BLM (T2)	1.50% BLM (T3)	2.00% BLM (T4)	0.20% Vit.C (T5)	p-value	SEM

GPx (U/ml)	419.6	301.7	226.5	230.3	244.0	0.6609	4.1
MDA (nmol/ml)	1.2854	1.5314	1.7416	1.7618	1.7467	0.6818	0.21
SOD (U/ml)	4477.6^{b}	1492.5^{c}	1726.4^{b}	1865.7^{c}	8955.2^{a}	0.0019	9.81
CORT (U/ml)	1.5250	1.7317	1.7173	3.4865	2.5827	0.0548	0.25

Means with different superscripts (a, b and c) are significantly different (p< 0.05) , SEM= Standard error of mean. GPx = glutathione peroxidases, MDA = malondialdehyde, SOD = superoxide dismutase, CORT = corticosterone

DISCUSSION

The high phytochemical contents in diet 4 (2.0% BLM) appears better to alleviate heat stress and this is contrary to the report of Abubakar *et* al., (2021) and El-Wardany *et al.,* (2015). The increase in feed intake and weight gain with increasing BLM in the diet may be of positive value since inclusion of BLM at 2% level seems to improve the appetite of the broiler chickens with a resulting increase in weight gain comparable with and better than results from broiler chickens fed diet 5 (0.2% Vit. C). This observation is corroborated by the report of Li *et al*. (2017) who stated that the inclusion of *bamboo* leaves in broiler chicken diets improved body weight gain by 17.6% because of the presence of flavonoids. it has been hypothesized that flavonoids might play the role of growth hormones in animals (Havsteen, 2002), since flavonoids hydroxyl groups of aglycone are positioned in space in the same manner as estrogen's hydroxyl groups. This seems to indicate that the inclusion of BLM at of 2% level is the most efficient, and this dose-dependent impact may be the result of increase in concentrations of flavonoids in the diet. Earlier reports have shown that when birds suffer from challenges such as heat stress and immune suppression, growth performance would be affected (Yang *et al*., 2010). Authors have demonstrated that supplementing broiler chicken diets with bamboo leaf flavonoids at a concentration of 1.6% could mitigate the growth-inhibiting effects of heat stress and immunological suppression in broilers (Qi *et al*., 2014). It could be inferred that flavonoids in bamboo leaves may have been responsible for the observed growth improvement observed as seen in this study. The high feed conversion ratio of the diet contained 2% bamboo leaf that comparable with the diet containing vitamin C suggesting that the bamboo leaves enhanced the feed conversion ratio of the birds with little or no stress and is in line with the report of El-wardany *et al*. (2015) that bamboo leaf can be fed to reduce stress. The inclusion of the bamboo leaf in the diets fed in this study regardless of the level did not affect the percent mortality across the treatment groups and suggesting that it is non-detrimental to the health of the bird, though this is contrary to the report of Krzyszt *et al*. (2011).
The non-significant difference among glutathione peroxidases (GPx), corticosterone (CORT), and malondialdehyde (MDA) in all the diets may indicate less-observable stress within the birds during the study**.** Earlier authors have demonstrated that exposure to the bamboo leaf can remarkably raise the levels of the enzyme superoxide dismutase and glutathione peroxidase, and corticosterone hormone in birds that have been subjected to heat stress, and can enhance the birds' antioxidant potential (Liu *et al*., 2014). Research shows that the ability of flavonoids to stimulate antioxidant enzymes, chelate metal catalysts, transfer electrons to free radicals, and suppress oxidases seems to be responsible for the antioxidant effects that flavonoids have in living systems (Wan *et al*., 2016). We postulated that with the increasing the BLM in the diet, increased the antioxidant capacity of the diets since bamboo leaf has a peroxide scavenging capacity (Ni *et al*., 2011). Inhibition of the synthesis of thiobarbituric acid-reactive compounds can be attributed, in part, to flavonoids and polyphenols (Niu *et al*., 2016). In addition, research has demonstrated that broilers given plant extracts high in flavonoids, polyphenols, and polysaccharides are able to increase their capacity to scavenge free radicals (Yu *et al*., 2019).

CONCLUSION

This study concludes that bamboo leaf meal inclusion at 2% in the broiler feed was able to improve performance, alleviated heat stress and had no adverse effect on health of broiler chickens. Furthermore, broiler chickens fed 2% BLM inclusion showed improvement in terms of growth performance despite being reared under heat stress. This improvement in performance may not be unconnected to the induction of the excessive release of glutathione peroxidase (GPx) and superoxide dismutase (SOD), and reduced levels of corticosterone (CORT) and malondialdehyde (MDA) which positively influenced performance.

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Sub-Theme D: Biosafety issues in agriculture, Smart agriculture and climate changes, Agriculture engineering and mechanization strategies
(Cont'd)

Demographic And Controlling Factors Connected With Biosecurity Compliance On Fish Farms In Southern Area of Lagos State, Nigeria.

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ABSTRACT

Biosecurity protocols are often poorly managed on fish farms. This study explored biosecurity practices on 96 fish farms, examining the demographic and management factors related to good biosecurity measures in some southern Local Government Areas in Lagos State, Nigeria. A structured and pretested interviewer-administered questionnaire was used to obtain information on demographic and management factors, and on the procedural biosecurity plans in these farms. A scoring system was developed to assess biosecurity measures, bivariate and multivariable analyses were done to determine forecasters for good biosecurity score on the fish farms. The bivariate analysis of factors associated with biosecurity compliance shows that the majority of the fish farmers are between the ages of 45-50 (30.12%), 78.13% had Tertiary Education as qualification, a group that showed more biosecurity observance, 85.43% are full time farmers with over 10 years of experience. In the multivariate logistic regression, the education status of the fish farmer/manager (OR = 3.6, 95% CI = 1.0 – 4.1, p = 0.01), and fish farmers' occupation (OR = 1.8, 95% CI = 0.2 – 3.7, p = 0.04) are the only significant forecasters of good biosecurity compliance. Factors such as age of farmer/ farm manager, many years of experience and tertiary educational achievement should be considered in the design and implementation of biosecurity measures on fish farms. Mortality rates on fish farms could become a good indicator to maintain practical biosecurity levels.

Keywords: Biosecurity, Southern Lagos, Education, Experience, Fish Farms

INTRODUCTION

Biosecurity measures are set of health controls and activities taken to prevent entry of new infectious diseases into animal herds and to avoid their spread through exit of the disease agent (Barcelo & Marco, 1998). FAO (2008) defines it as the implementation of measures that reduce the risk of the introduction and spread of disease agents; it requires the adoption of a set of attitudes and behaviors by people to reduce risk in all activities involving domestic, captive/ exotic and wild animals and their products or infection from a premise

Aquaculture loses millions of dollars in revenue annually due to aquatic animal diseases. Disease outbreaks continue to threaten profitable and viable aquaculture operations throughout the world. As a result, aquaculture biosecurity programs that address aquatic animal pathogens and diseases have become an important focus for the aquaculture industry. (O'Bryen.2006Aquaculture increasing global importance is directly related to the contribution it makes in reducing the gap between supply and demand for fish products. According to Faturoti (2010). Aquaculture has been clearly demonstrated to be an economically viable, private enterprise in Nigeria. Aquaculture has great potential for food production and the alleviation of poverty for people living in coastal areas, many of who are among the poorest in the world (Tisdell, 1999).

In Nigeria aquaculture is a potential economic investment but different challenges resulting to numerous losses affect the final fish product and returned on investment.

The general objective of this paper is to assess the level of aquaculture biosecurity compliance of fish farms in the southern area of Lagos State, Nigeria. It will also suggest measures which will strengthen aquaculture through the development of aquaculture biosecurity regulations in Nigeria to meet international standard.

MATERIALS AND METHODS

Study Design

Ninety-six (96) registered fish farms were randomly sampled across four local governments (Epe, Eti-osa, and Ibeju -Lekki), in Lagos-Nigeria.

Questionnaire Design and Administration

A structured questionnaire was designed to assess biosecurity measures (n = 34) on the fish farms based on three key areas as described by Barceló & Marco (1998) which are the locations, isolation of replacement stock, and the conditions of the farm. The questionnaire was interviewer-administered to fish farmers or the farm manager on their various farms. Compliance with biosecurity measures relating to distances were adjudged based on the farmers' responses and direct non-participant observation.

Data Analysis

The data were entered into Microsoft Excel. Analysis was done in Statistical Package for Social Sciences (SPSS). A scoring system was developed for the 34 variables to determine the biosecurity level on the fish farms. An equal weight was ascribed to all the biosecurity components, with a score of 0 and 1 for each variable. The presence of each variable was given a score of 1, while its absence was given a zero-score based on the risk effect of such variable. The total obtainable score was 34, and the higher the score, the higher the indication of a better biosecurity level. A score greater than 18 was graded good, the cut off score which addressed our interest on those who implemented a little above 50% of all set of items. Descriptive statistics was done and the associations between the considered demographic and management factors with biosecurity compliance level on the fish farms were assessed by finding the odds ratios. Statistical significance was computed by the Fisher's exact test at the 95% confidence interval. Multivariate logistic regression was used to decide predictors for good biosecurity score. Collinearity among predictors was also checked using Chi-square test for binomial variables. A forward selection method was used. The goodness of fit of the model was checked using the Pearson goodness of fit test. In the final models, only variables that were found to significantly affect the outcome at $P < 0.05$ were kept.

RESULTS

Demography and Management Parameters

Most of the fish farmers were between the age-groups of 40-45 (21.88%) and 46-50 (30.21%). Majority (60.34%) of the farmers were married. There are more male farmers (80.21%) than female (19.79%). A high number of them had tertiary education (78.13%), while just a few of them (17.71%) had secondary education as their highest level of education. Only a few (14.58%) had fish farming as their secondary occupation, while the rest (85.43%) were fulltime fish farmers. Several of them (43.75%) had more than 11 years' experience in fish farming, while the rest (56.25%) had lesser years of experience. Out of all 96 fish farms visited, over half (52.08%) of them were practicing the earthen pond system, while the other half (47.92%) had concrete, plastic, and re-circulatory system. Similarly, over half (53.13%) of the fish farms were practicing intensive culture system, while the rest were semi-intensive (27.08%), and extensive culture system (19.79%).

Table 1: *Bivariate analysis of factors associated with biosecurity compliance on 96 fish farms in Lagos-Nigeria, 2021.*

Variables	Good Compliance n = 20 (%)	Poor Compliance n = 76 (%)
Age of fish farmer/ manager (years)		
16 – 21	0 (0.0)	4 (5.26)
22 – 27	1 (5.0)	3 (3.95)
28 – 33	3 (15.0)	14 (18.42)
34 – 39	3 (15.0)	10 (13.56)
40 – 45	5 (25.0)	16 (21.05)
46 – 50	6 (30.0)	23 (30.26)
> 52	2 (10.0)	6 (7.89)
Marital status		

Single	6 (30.0)	23 (30.1)
Married	11 (55.0)	47 (61.8)
Widow	3 (15.0)	6 (7.9)
Sex		
Male	9 (45.0)	68 (89.5)
Female	11(55.0)	8 (10.5)
Religious status		
Christian	13 (65.0)	62 (81.6)
Islam	7 (35.0)	14 (18.4)
Other	0 (0.0)	0 (0.0)
Education status		
No formal education	0 (0.0)	4 (5.3)
Primary education	0 (0.0)	0 (0)
Secondary education	1 (5.0)	16 (21.1)
Tertiary education	19 (95.0)	56 (73.7)
Fish farming occupation		
Main occupation	16 (80.0)	66 (86.8)
Secondary occupation	4 (20.0)	10 (13.2)
Experience in aquaculture (years)		
< 1	0 (0.0)	0 (0.0)
2 – 4	2 (10.0)	11 (14.5)
5 – 7	5 (25.0)	24 (31.6)
8 – 10	5 (25.0)	7 (9.2)
> 11	8 (40.0)	34 (44.7)
Type of specie		
Catfish	20 (100)	62 (81.6)
Tilapia	0 (0.0)	14 (18.4)
Others	0 (0.0)	0 (0.0)
Pond System		
Earthen	11 (55.0)	39 (51.3)
Concrete	2 (10.0)	11 (14.5)
Plastic	0 (0.0)	17 (22.4)
Re-circulatory system	7 (35.0)	9 (11.8)
Cage culture	0 (0.0)	0 (0.0)
Tarpaulin	0 (0.0)	0 (0.0)
Others	0 (0.0)	0 (0.0)
Culture system		

Intensive	13 (65.0)	38 (50.0)
Semi-intensive	5 (25.0)	21 (27.6)
Extensive	2 (10.0)	17 (22.4)

Table 2: *Logistic Regression of factors associated with biosecurity compliance on 96 fish farms in Lagos-Nigeria, 2021.*

Variable	**OR**	**95% CI**	**P value**
Education status			
Secondary education	Ref.		
Tertiary education	3.6	[1.0 , 4.1]	0.01
Fish farmers' occupation			
Secondary occupation	Ref.		
Main occupation	1.8	[0.2 , 3.7]	0.04

In the multivariate logistic regression, the education status of the fish farmer/manager (OR = 3.6, 95% CI = 1.0 – 4.1, p = 0.01), and fish farmers' occupation (OR = 1.8, 95% CI = 0.2 – 3.7, p = 0.04) are the only significant predictors of good biosecurity compliance (Table 2).

CONCLUSION:

In the multivariable analysis, the age of pig farmer or manager and higher level of education are significant predictors for good biosecurity score. Farmers or managers who were average age (i.e. between age 45 and 50) were much more likely to have good biosecurity score than those who were younger (i.e. less than 45 years). This finding is similar to that reported by Schemann *et al*. (2011) who reported lower compliance in younger people (less than 25years) involved with fish farming in Australia. This, however, is contrary to the findings of Sayers *et al*. (2013); that younger dairy farmers had higher likelihood to implement biosecurity measures than their middle-aged counterparts. The difference in the age categorization may explain the contrast in the compliance level.

RECOMMENDATION:

Good biosecurity measures on fish farms will always reduce the risk of losses from infectious pathogens. It is important to know the fish and water sources to ensure that specific pathogens do not enter farm facility in any way. Quarantine measures, testing and continuous monitoring of fish health protocols throughout the production cycle are key. Good husbandry, biosecurity designs should carefully be designed with the facility's sanitation, disinfection, system's management schemes and personnel compliance in mind. Record keeping for traceability purposes and continuous educational seminars to upgrade the status quo are important.

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Sub-Theme E: Postharvest handling, Product development and quality control and Food science, Technology, Home science and Dietetics

(Cont'd)

Isolation And Characterization Of Air Microflora In Clinical Laboratories At Igboora (Ibarapa Central), Oyo State

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ABSTRACT:

Microflora contamination in laboratories and hospitals is becoming a serious problem worldwide, and the characterization of such contaminants offers hope for the treatment of some infections acquired in hospitals and laboratories. Microflora contamination in benches, floors, media and equipment can be affected by temperature, humidity and nutrient media in laboratories and media storage conditions. This study was carried out to isolate and characterize air microflora in selected clinical laboratories at Igboora (Ibarapa Central) based on morphological, biochemical properties and persistent bacteria in laboratory sites after disinfection with sodium hypochlorite. The samples were collected from four laboratories. The isolation of pure cultures was performed on the basis of morphological differences, using the shape of the colony, elevation, pigmentation and size to distinguish bacterial and fungal contaminants. The results showed that; the laboratory sites examined were contaminated with different microbes. Macroscopic and microscopic observations of fungi confirmed the presence of Aspergillus niger, Fusarium oxyporum, Aspergillus ochraceus and Alternaria alternata on sink and biosafety cabinets, the persistent bacteria identified were Bacillus cereus, Pseudomonas aeruginosa and Staphylococci aureus. The contaminants were similar to the standard strains, but there was a significant difference in contamination in the four selected laboratories (analysis of variance (ANOVA $P<0.05$). Bacterial and fungal contaminants remain a threat on laboratory surfaces and equipment. Therefore, the need to either increase the concentration or change the disinfectant commonly used.

Keywords: Isolates, Microflora, Bacteria, Fungi, Contaminant, Laboratories, Disinfectant

INTRODUCTION

Microflora is a term that refers to a community of bacteria/fungi that exist on or inside the body, and possess a unique ecological relationship with the host. This relationship encompasses a wide variety of microorganisms and the interaction between microbes. These interactions are often a mutualistic relationship between the host and autochthonous flora. Microflora responsible for harmful diseases are often allochthonous flora (Shiva et al., 2010). Microflora contamination in laboratories and hospitals is becoming a serious problem worldwide, characterization of such contaminants helps in treating some laboratory-acquired infections (LAI). There are laboratory quality and biosafety practices that are overlooked, which lead to microflora contamination in large numbers in the cell cultures and in the laboratory environment which may lead to (LAI) to people. The contamination risks pose danger to laboratory personnel as well as increase the costs of in-house cell culture procedure. LAI are the infections symptomatic or asymptomatic acquired through laboratory or laboratory related activities (Traxler et al., 2013). This work determined the microbial contaminations in microbiology laboratories that could cause laboratories acquired infections so as to assist personnel in laboratories to be careful when performing standard manipulations of microbiological specimens in cell cultures and training the personnel on capacity development in monitoring and evaluation of microflora contaminants in laboratories so that the upgrading policy on standard operating procedures could be developed in the laboratories (Negi et al., 2011)

Media preparation and sample collection

The study was carried out in the research laboratory of Oyo State College of Agriculture and Technology, Igboora, Ibarapa Central, Local Government. Nutrient agar (28 g), MacConkey (17 g), Mannitol Salt agar (15 g) and Potato Dextrose agar were weighed and dissolved in 1000 ml of distilled water. The agars were sterilized at 121°C for 15 min. Nutrient broth (with the same ingredients except agar) was prepared by suspending 13.0 g of nutrient Agar in 1000 ml ((Traxler et al., 2013). The media were cooled to a little below 45°C and were poured on plates to solidify. Plates were taken to the laboratories (Mak Mercy, Oluyole, Olugbon, World Health), and were opened and exposed at chosen location (cabinet and sink) for a period of 5-10 mins for contamination by laboratories environmental microflora.

Isolation of bacterial and fungal contaminants

The inoculated Potato dextrose agar (PDA) plates were incubated at a temperature of 25 °C for 72 h while Nutrient Agar plates and MacConkey plates were incubated at 37 °C for 24 h for fungal growth and bacterial growth respectively. The fungi and bacteria that grew on the media were sub-cultured into pure culture.

Identification of bacterial contaminants using biochemical methods

Bacteria identification was done based on results obtained from Gram staining, morphology and motility test, catalase production, oxidase test, indole production, citrate utilization, urease activity, hydrogen sulphide production, gelatin hydrolysis, starch hydrolysis and carbohydrates utilization.

Isolation of bacterial strains persistent to sodium hypochlorite disinfection

Three and half percent of sodium hypochlorite disinfectant (jik) used in the biosafety labs was used to sterilize the biosafety walls, benches and floor of incubating rooms in the laboratories for ten minutes to determine the viable bacteria after which opened plates were positioned in areas mostly used frequently used by the laboratory personnel. Jik is mostly used as it has carbonates, silicates, polyphosphates and chlorine water which decontaminate surfaces therefore leaving the place sterile.

RESULTS AND DISCUSSION

Table 1 and 2 revealed the rate of occurrence of bacterial and fungal isolates at chosen sites in the hospital laboratories; there was a significant difference ($p<0.05$) among the bacterial and fungal isolates from all the sites and MAK Mercy sinks (33.10%) and cabinets (11.87%) had the highest occurrence, followed by MAK Mercy cabinet fungi (31.84%) while no bacteria and fungi was observed and reported for Olugbon, world health and Oluyole cabinets (0.00%). The variation in the level of contamination of the different laboratories examined could be due to high rate of movement and communication of people who brought samples into the laboratory from outside and within the hospitals and according to Pradeep et al. (2020), living biological contaminants can be transmitted by infected people, animals and indoor air, and they can also travel through the air to get inside the buildings. High occurrence microbes in one laboratory than the other could also be due to the level of population in the room as reported by Moldoveanu (2014) that the presence of bacteria in a room indicates the presence of people and their levels may get high when the building is heavily populated.

Points of observation for microflora		
Clinical laboratories	Percentage Occurrence of bacteria isolates (%)	
	Sink	Cabinet
Mak	33.10b	11.87a
Olu	20.14c	00.00
W	22.70d	3.96e
O	3.96e	4.31f

Table 1: Occurrence of bacteria at chosen sites in Igboora

Key; Mak- Mak Mercy lab, Olu-Olugbon lab, W-World health lab, O- Oluyole lab

Table 2: Occurrence of fungi at chosen sites in Igboora

Points of observation for microflora		
Clinical laboratories	Percentage Occurrence of fungi isolates (%)	
	Sink	Cabinet
Mak	00.00	31.84g
Olu	13.41h	16.76i
W	24.02j	00.00
O	13.97k	00.00

The identity of the bacterial and fungal isolates from the different hospital laboratories in Igboora is shown in table 3. The isolates were Staphylococcus aureus, Baciilus cereus, Pseudomonas aeruginosa, Escherichia coli, Salmonella Typhi, and Salmonella serovar Typhimurium. The frequent occurrence of B. cereus and Salmonella from the cabinet and sink sites of the laboratories in this study disagrees with the finding of Poppert, et al. (2010) where microorganisms isolated and identified from different laboratory locations including walls, tables and floor were predominantly Corynebacterium sp. and Pseudomonas sp.

Table 4 showed the rate of occurrence of persistent bacteria in the four selected laboratories after disinfection with Sodium Hypochlorite (JIK) where 20.83% of Staphylococcus aureus were persistent in MAK Mercy cabinet, Bacillus cereus (16.67%, 15.63%) were persistent in Olugbon sink and carbinet. Mac Salmonella serovar typhimurium, Bacillus cereus, Salmonella typhi, Pseudomonas aeruginosa, Escherichia coli, but P. aeruginosa, S. aureus and B. cereus were found to be high after disinfectant with Sodium hypochlorite (Jik). This is similar with the research of Salgaado et al. (2015) and Isenberge (2011) where they reported that Shigella spp., Pseudomonas aeruginosa, Corynebacteria spp., Bacillus spp. and Staphylococci spp. were major resistant bacteria contaminants in biosafety laboratories in a University teaching hospital. Presence of large number of selected persistent bacteria in this study showed that the laboratory staffs may have not critically adhered to safety rules.

Fungal contaminants found associated with the cabinet site of the laboratories were Aspergillus niger, Fusarium oxyporum, Aspergillus ochraceus and Alternaria alternate which was in an agreement with findings of Salgado et al. (2015) who reported Cladosporium, Penicillium, Aspergillus and Alternaria as the most common fungi in biosafety cabinets. Regularly used furniture has been a major source of fungal spores and shade around the house has also increased indoor fungi population in fivefold (Saglani et al., 2015) since fungi grow anywhere indoor, where there is moisture and a food source in which many building materials consist of cellulolytic materials that are particularly suitable for fungi growth when they are wet, other materials that also support fungi growth include dust and paints.

Table 3: Biochemical Identification of bacterial isolates from Igboora clinical laboratories

Isolate code	Shape	Gram Rxn	Indole	motility	Catalase	Coagulase	Oxidase	Citrate	Growth in KCN	Nitrate Reduction	Methyl Red	Voges-Proskauer	Endospore	Urase	Glucose	Fructose	Galactose	Maltose	Sucrose	Lactose	Probable Bacteria
Olu(s)	Rod	+	-	+	+	-	-	+	+	+	-	+	+	-	+	+	-	+	+	-	Bacillus cereus
Olu(c)	Rod	+	-	+	+	-	-	+	+	+	-	+	+	-	+	+	-	+	+	-	Bacillus cereus
O(s)	Rod	-	-	+	+	-	+	+	-	+	-	-	-	-	+	+	-	-	-	-	Pseudomonas aeruginosa
O(c)	Rod	-	+	+	+	-	-	-	-	+	+	-	-	-	+	-	-	-	+	+	Escherichia coli
Mak(s)	Rod	-	-	+	+	-	-	+	-	+	+	-	-	-	+	+	-	+	-	-	Salmonella serovar Typhimurium
Mak(c)	Cocci in Chain	+	-	-	+	+	-	+	-	+	+	+		+	+	+	+	+	+	+	Staphylococcus aureus
W(s)	Rod	-	+	+	+	-	-	-	-	+	+	-	-	-	+	-	-	-	+	+	Escherichia coli
W(c)	Rod	-	-	+	+	-	-	-	-	+	+	-	-	-	+	+	-	+	-	-	Salmonella Typhi

KEY: Olu(s)-Olugbon sink. Olu(c)-Olugbon cabinet, O(s)-Oluyole sink, Olu(c)-Oluyole cabinet, Mak(s)-Mak Mercy sink, Mak(s)-Mak Mercy cabinet, W(s)-World health sink, W(c)- World health cabinet

Table 4: Occurrence of persistent bacteria at chosen site in Igboora

Isolates codes	Percentage Occurrence of persistent bacteria isolates (%)	Probable Bacteria
Mak(c)	20.83l	Staphylococcus aureus
Mak(s)	9.38m	Salmonella serovar Typhimurium
Olu(s)	16.67n	Bacillus cereus

Olu(c)	15.63n	Bacillus cereus
W(s)	7.29p	Escherichia coli
W(c)	14.58q	Salmonella typhi
O(s)	15.62o	Pseudomonas aeruginosa
`	7.29p	Escherichia coli

Values with different letters are highly significantly different ($P<0.05$)

CONCLUSION

All tested sites had microflora contaminants. The contaminated areas were in sink environment, and biosafety cabinets. Each site contained more than one microflora contaminants. The isolated bacteria and fungi contaminants were similar based on morphological and biochemical characteristics among the laboratories. Pseudomonas sp., Staphylococcus aureus and B. cereus were highest persistent bacteria isolates after disinfection with sodium hypochlorite (Jik)

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