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Research Article

Complementary Effects of Rice husk and Nitrogen Fertilizer on the Growth, Yield and Nutrient Uptake of Cocoyam (Colocasia esculenta (L.) Schott)

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Abstract: Cocoyam is one of the staples in the South east and South south zone of Nigeria. There is decline in cocoyam production in these areas because of inherent low fertility level of the soil occasioned by intensive agriculture with little or no fertilizer input. This work investigated the complementary effects of rice husk and nitrogen (N) fertilizer on the growth, yield and nutrient uptake (nitrogen, phosphorus, potassium) of cocoyam (*Colocasia esculenta* (L.) Schott) var. cocoindia. The treatments comprised two levels of application of rice husk (0 and 15 t/ha) and three levels of nitrogen (0, 50 and 100 KgN/ha) which were factored and fitted into a randomized complete block design replicated thrice. Analysis of variance (ANOVA) was employed in data analyses and LSD was used to partition significant means at $P<0.05$. Rice husk application increased significantly growth, yield and P and K uptakes of cocoyam compared to the control. Nitrogen fertilization had no significant effect on cocoyam yield. However, 100 kgN/ha significantly increased leaf area index, number of suckers and nitrogen uptake over the control. Increasing nitrogen fertilizer above 50 kgN/ha decreased significantly P and K uptakes. Significantly higher yield (13.11 t/ha) was obtained with combined application of 15 t/ha rice husk plus 100 kgN/ha compared to when either rice husk (10.53 t/ha) or nitrogen fertilizer (8.82 t/ha) was applied alone or the control (6.57 t/ha). This rate, 15 t/ha rice husk + 100 kgN/ha, is therefore recommended for improved cocoyam production to enhance food security in Nigeria.

Keywords: cocoyam; food security; nitrogen; nutrient uptake; rice husk; yield
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Introduction

Cocoyam (*colocasia esculenta* (L.) Schott) a member of the family Araceae, is a starchy tuber crop grown largely for its edible corms, which are eaten after boiling, frying or roasting. The corms can be boiled, ground into paste and then used as a soup thickener. The leaves of the plant are also edible and are usually consumed as a vegetable. Cocoyam is an excellent source of carbohydrate; It has been reported to be an ideal source of carbohydrate for diabetic patients because the starch grains are small in size and are easily digestible [1,2]. Cocoyam contains dietary fiber and higher protein contents than most of the tropical root crops including yam and cassava; it contains several vitamins and minerals [3]. Cocoyam also contains bioactive compounds, which have been reported to possess antioxidant, antibacterial, pesticide, anti-inflammatory property and inhibitory effects of some breast and prostrate cancer [4,5].

In Nigeria, cocoyam has been widely cultivated and consumed in the southeast and south agricultural zones for decades [6] although it is not as highly valued as other staple tuber crops like yam and cassava [7]. This crop is regarded as a poor man's food or a woman's crop because it is casually cultivated by small-scale farmers, mostly women [8] with or without input of fertilizer be it organic or organic. Therefore, it has lagged behind in research attention and in production. However, the increased awareness of the industrial and export potential of cassava has necessitated intensive agronomic investigation into increasing the productivity of some relatively obscure, casually cultivated and localized crop like cocoyam as alternative food sources [9]. Therefore, increased production and proper utilization of cocoyam may help to contribute to food security, nutrition, health and income generation for the growing population of Nigeria.

A major constraint to intensive production of cocoyam in the south and south eastern agroecological zone of Nigeria is the low level of the inherent fertility of the soil [10]. Application of inorganic fertilizer as a way of increasing soil fertility and hence crop productivity is usually accompanied by high rate of leaching because of the high rainfall experienced in this zone [11]. More so, the escalating cost and scarcity of inorganic fertilizer in these areas have made it impracticable for use by poor resource farmers in increasing crop productivity. Organic manures are not easily leached from the soil [12]; they last long in the soil but have the disadvantage of being bulky and required in large quantity in order to meet plants' nutrient need [13].

Many researchers have reported that appropriate combination of organic and inorganic fertilizers is a practicable approach to overcome soil fertility constraint and consequently enhance crop productivity [9,14-17]. There is want of information on the combined effect of rice husk and inorganic fertilizer on yield and nutrient uptake of cocoyam. Therefore, the objectives of this study were to evaluate the effects of rice husk and nitrogen fertilizer on the growth, yield and nutrient uptake of cocoyam.

Materials and methods

Study location

This study was conducted in the field at the botanical garden of Plant Science and Biotechnology, Abia State University, Uturu, Abia State, Southeast, Nigeria, located at Longitude 07° 46´ North and Latitude

05° 76´ East. The mean relative humidity of the study site is about 70 - 90%. The mean temperature range is 22.6 - 34.5°C; and the mean annual rainfall is in the range of 2000 - 2200 mm [18].

Sources of materials

Cocoyam (var. cocoindia) cormels and the rice husk used for this study were sourced from a local market in Akaeze and Ishiagu, respectively, both in Ivo LGA of Ebonyi State, Nigeria. Composite sample of the rice husk was air-dried, ground and analyzed for its nutrient composition using the methods described by Motsara and Roy [20]. The analysis revealed that the rice husk used is composed of 0.34% N, 11.1% P, 3.72% K, 0.529% Mg, 8.63% Ca, 1.32% Na and 52.7% organic matter (OM)

Land preparation and soil sampling

The site was cleared of grasses, ridged manually and then marked into three blocks. Each block was divided into six experimental plots, thus giving a total of eighteen plots. Each plot measured 3m x 3m ($9m^2$). Composite soil samples were collected from different locations in the field using soil auger to a depth of 20 cm. The soil sample was sun-dried, sieved using 2 mm mesh and analyzed for its physicochemical using standard methods as described by AOAC [19] and Motsara and Roy [20]. Results of the soil analysis indicated that the experimental soil was slightly acidic (pH 6.4) and of low fertility status with the following nutrient contents: 0.029% N, 12.0% P, 0.277% K, 0.291% Mg, 9.08% Ca, 1.6% Na, and 1.28% OM.

Experimental design and treatment application

The treatments were two levels of application of rice husk (0 and 15 t/ha) and three levels of nitrogen (0, 50 and 100 kgN/ha), which were factored and fitted into a randomized complete block design with three replicates. The rice husk 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. Nitrogen was applied in the form of urea at 28 days after planting (DAP) using band placement method. Blanket application of phosphorus fertilizer at the rate of 40 kgP_2O_5/ha was applied to all the plots with the exception of the control and the plot that received only rice husk.

Planting

The cocoyam cormels were planted on the crest of ridges at a depth of 15 cm on 3rd May 2016. One cormel was planted per hole at a planting distance of 0.5m x 1m. The site was kept weed free by manual weeding.

Data collection and analysis

Data were collected on the following plant growth characteristics: plant height, number of leaves, Leaf area, lead area index (LAI), number of suckers. These growth data were collected at 28 days interval. At physiological maturity, the following yield and yield attributes were taken: number of corms per plant, corm weight (kg/plant), cormel weight (kg/plant), total tuber yield (t/ha). Data were also collected on uptake of nutrients – nitrogen, phosphorus and potassium, by the cocoyam corms. Data generated were then subjected to Two Way ANOVA using Genstat Discovery Edition 3 Package of 2007 and significant means were separated using Fishers' Least Significant Difference at $P<0.05$.

Results

Growth characteristics

Analysis of results showed that rice husk application significantly (P<0.05) increased plant height of cocoyam over the control in all the days sampled (Table 1). On the contrary, application of nitrogen fertilizer had no significant effect on plant height of the cocoyam in all the days sampled so also interaction effect.

Tab. 1 Effect of the soil inputs on cocoyam plant height (cm) at different sampled days

	Days after planting (DAP)			
Treatment	28	56	84	112
Rice husk (t/ha)				
0	12.2	31.0	37.1	37.4
15	17.9	42.7	48.1	46.6
LSD (0.05)	4.2	7.4	9.6	9.1
Nitrogen (kgN/ha)				
0	15.4	35.7	40.6	40.8
50	15.2	37.0	43.5	43.1
100	14.5	37.9	43.8	42.1
LSD (0.05)	NS	NS	NS	NS

Number of leaves was significantly (P<0.05) increased by the application of rice husk in all the sampled days in relation to the control with the exception of 112 DAP where significant difference was not found. Significant effects of nitrogen fertilizer application and also interaction on number of leaves of cocoyam were not found (Table 2).

Application of rice husk increased significantly (P<0.05) LAI of cocoyam in all the sampled period with the exception of 112 DAP (Table 3). Nitrogen fertilization also increased significantly (P<0.05) LAI of cocoyam compared to the control at 56 and 84 DAP. Increasing nitrogen rate from 0 to 100 kg/N significantly (P<0.05) increased LAI. Interaction between rice husk and nitrogen fertilizer was significant only at 84 DAP. Combined application of rice husk and nitrogen fertilizer significantly increased LAI compared to when either of the fertilizers was applied alone. The highest LAI was obtained with combined application of rice husk and nitrogen fertilizer at 15 t/ha and 100 kgN/ha, respectively.

Tab. 2 Effect of the soil inputs on number of leaves of cocoyam at different sampled days

	Days after planting (DAP)			
Treatment	28	56	84	112
Rice husk (t/ha)				
0	3.3	8.5	14.9	18.4
15	6.1	15.3	22.8	20.8
LSD (0.05)	1.3	4.1	5.6	NS
Nitrogen (kgN/ha)				
0	4.8	10.3	15.7	17.8
50	4.7	12.1	18.8	20.1
100	4.5	13.0	21.2	20.9
LSD (0.05)	NS	NS	NS	NS

Tab. 3 Effect of the soil inputs on cocoyam leaf area index (LAI) at different sampled days

	Days after planting (DAP)			
Treatment	28	56	84	112
Rice husk (t/ha)				
0	0.08	0.78	1.65	1.83
15	0.25	2.93	3.76	2.35
LSD (0.05)	0.09	0.30	0.71	NS
Nitrogen (kgN/ha)				
0	0.19	1.12	1.55	1.70
50	0.16	1.79	2.56	2.17
100	0.15	2.65	4.00	2.40
LSD (0.05)	NS	1.29	1.40	NS

Tab. 4 Effect of the soil inputs on number of suckers of cocoyam at different sampled days

	Days after planting (DAP)			
Treatment	28	56	84	112
Rice husk (t/ha)				
0	1.0	1.7	3.4	4.1
15	1.9	3.0	5.1	5.6
LSD (0.05)	0.6	0.9	1.3	1.2
Nitrogen (kgN/ha)				
0	1.5	2.0	3.5	4.2
50	1.4	2.3	4.2	4.7
100	1.5	2.7	5.0	5.7
LSD (0.05)	NS	NS	0.7	0.9

Cocoyam plants grown on soils treated with rice husk produced significantly ($P<0.05$) higher number of suckers compared to the control in all the days sampled (Table 4). Similarly, plants that received nitrogen fertilizer produced significantly more suckers than the control from 84 DAP. Increasing nitrogen fertilizer from 0 to 100 kgN/ha increased significantly the number of suckers produced. Effect of interaction on number of suckers produced was significant on 56 and 112 DAP. Combined application of rice husk and nitrogen fertilizer at the highest rate of 100 kgN/ha gave significantly the highest number of suckers.

Yield and yield attributes

The results on cocoyam yield are presented in Table 5. Application of rice husk increased significantly ($P<0.05$) the number of cocoyam corms/cormels produced as against the control. On the other hand, effects of nitrogen and interaction between rice husk and nitrogen on number of corms/cormels produced were not significant.

Corm weight was not significantly affected by the application of the fertilizers. More so, significant effect of interaction on corm weight was not found. Cormel weight was significantly ($P < 0.05$) increased by the application of rice husk. On the contrary, nitrogen fertilizer application had no significant effect on cormel weight. Interactions between rice husk and nitrogen fertilizer on cormel weight and total tuber weight were significant. Application of 15 t/ha rice husk plus 100 kgN/ha gave significantly the highest cormel and total tuber weight compared to when either of the fertilizers was applied alone.

Tab. 5 Effect of the soil inputs on yield and yield components of cocoyam at maturity

Treatment	NC	CW (Kg/plant)	CoW (Kg/plant)	TTY (t/ha)
Rice husk (t/ha)				
0	12.0	99.1	304.4	8.07
15	18.3	102.2	473.3	11.51
LSD (0.05)	2.6	NS	84.4	1.02
Nitrogen (kgN/ha)				
0	13.6	91.0	336.6	8.55
50	15.0	97.7	387.8	9.71
100	16.6	113.2	442.2	11.11
LSD (0.05)	NS	NS	NS	NS
Rice husk x Nitrogen (Interaction)				
R_0 x N_0	10.0	88.7	239.8	6.57
R_0 x N_{50}	12.3	93.3	333.4	8.53
R_0 x N_{100}	13.8	115.3	340.0	9.11
R_{15} x N_0	17.1	93.2	433.4	10.53
R_{15} x N_{50}	17.7	102.0	442.2	10.88
R_{15} x N_{100}	19.3	111.0	544.3	13.11
LSD (0.05)	NS	NS	100.6	2.10

NC = number of corms; CW = corm weight; CoW = cormel weight; TTY = total tuber weight; NS = not significant

Nutrient uptake

Nutrient uptakes by the cocoyam corms were significantly (P<0.05) affected by the application of the fertilizers (Table 6). Rice husk application increased significantly (P<0.05) uptakes of P and K in relation to the control but had no significant effect on N uptake. Application of nitrogen fertilizer at 100 kgN/ha increased significantly (P<0.05) N uptake over the lower rate of 50 kgN/ha and the control whereas cocoyam corms under 50kgN/ha and the control had statistically similar N uptake values. P and K uptakes were increased significantly by application of 50 kgN/ha in relation to the control and the higher rate of 100 kgN/ha. Increasing nitrogen rate above 50 kgN/ha decreased uptakes of P and K. Significant interactions between rice husk and nitrogen fertilizer on uptake of nutrients were not found.

Tab. 6 Effect of the soil inputs on nutrient uptake of cocoyam at harvest

Treatment	N (%)	P (%)	K (%)
Rice husk (t/ha)			
0	0.052	2.82	36.68
15	0.015	3.53	50.03
LSD (0.05)	NS	0.43	12.51
Nitrogen (kgN/ha)			
0	0.008	2.97	37.77
50	0.009	3.58	49.98
100	0.083	2.97	42.31
LSD (0.05)	0.035	0.28	5.47

Discussion

The increases in growth parameters observed due to application of rice husk supports earlier report made by other scientists that application of organic manures plays a direct role in plants' growth and development as a source of necessary macro and micro nutrients in available forms during mineralization [21,22]. Nitrogen is one of the major plant nutrients and is involved in shoot development. This is evidenced in the significant increases observed in LAI and number of suckers as a result of nitrogen fertilization. However, there was relatively rapid increase in growth (plant height, number of leaves, LAI and number of suckers) within the first 3 months after planting. Sivan [23] reported shoot development with initiation of corm development during two to four months after planting. According to Tumuhimbise *et al*. [24] and Silva *et al*. [25], this period is marked by increase in plant height, number of leaves and leaf area.

Application of rice husk increased tuber weight by 60.3% over the control while nitrogen fertilizer applied at 50 and 100 kgN/ha increased tuber weight by 29.9% and 38.6% over the control, respectively. On the other hand, combined application of rice husk and nitrogen at 15 t/ha + 50 kgN/ha, and 15 t/ha + 100 kgN/ha increased tuber weight by 65% and 99.5% over the control, respectively. These results are in agreement with the reports of other researchers who found that combination of organic and inorganic fertilizers enhances growth and yield of crops compared to when either of them was applied alone due to increased nutrient use efficiency [9,15,26-,28]. In addition, increased yield observed with combined use of rice husk and nitrogen fertilizer is attributable to synergistic effects and improved synchronization of nutrient release and uptake by crops as reported by Palm *et al.* [13]. Ayoola and Adeniyan [29] reported that nutrient from mineral fertilizer enhance the establishment of crops while that from organic fertilizer promotes yield when both fertilizers are combined. This may be the reason for the non-significant effect of nitrogen fertilizer on yield and yield components of the crop. Moreover, several field research reports have indicated that high sustainable crop yields are only possible with integrated use of mineral fertilizers and organic manures [30]. The least performance of the plants in the control pots was an evidence of soil nutrients deficit.

Uptake of nitrogen was unaffected by rice husk application but was increased significantly (P<0.05) by the application of 100 kgN/ha over the lower rate of 50 kgN/ha and the control by 822% and 938%, respectively. The non-significant effect of rice husk application on N uptake may be attributable to the low content of nitrogen in rice husk. Khaled *et al*. [31] reported that application of fertilizers with high mineral contents enhanced their uptake by crops. Rice husk application increased significantly (P<0.05) uptakes of P and K by 25% and 36%, respectively over the control. Organic residues with high levels of minerals decompose and release into soil higher quantities of minerals which enhance their absorption by crops [32]. P and K uptakes were increased significantly by application of 50 kgN/ha in relation to the control by 21% and 32%, respectively and the higher rate of 100 kgN/ha by 21% and 16%, respectively. Increasing nitrogen rate above 50 kgN/ha decreased uptakes of P and K. This implies that excess of nitrogen may affect the uptake of potassium and phosphorus by cocoyam corms. Ojeniyi *et al.* [33] observed higher nutrient uptake of cocoyam (*Xanthosoma sagittifolium* (L.) resulting from application of organic manure. However, it was found that potassium was more abundant than the other nutrient elements in the cocoyam corms/cormels. This agrees with the reports of Mwenye *et al.* [34] and Iwuagwu *et al*. [35] who reported that K is the major mineral present in cocoyam.

Conclusion

This study revealed that whereas rice husk application increased both growth and yield of cocoyam, nitrogen fertilization promoted growth only. In addition, combination of rice husk and nitrogen fertilizer improved total tuber yield of cocoyam in relation to when either of the fertilizers was applied alone or the control. Maximum yield of cocoyam was obtained at integrated application of rice husk at 15 t/ha plus 100 kgN/ha. Uptakes of potassium and phosphorus by the cocoyam corms/cormels were significantly increased by sole applications of rice husk and 50 kgN/ha. On the contrary, 100 kgN/ha decreased significantly phosphorus and potassium uptakes but significantly increased nitrogen uptake. Amongst the nutrient elements, potassium uptake was higher than the other nutrients. It is therefore recommended that for increased cocoyam production, rice husk should be supplemented with nitrogen fertilizer.

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