Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.11, No.12, 2021

Effects of Mineral and Organo-mineral Fertilization on Sweet Potato (Ipomea batata {L} Lam) in Makurdi, Benue State, Southern Guinea Savanna Nigeria

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Abstract
A Research was conducted at the Experimental Farm of the University of Agriculture Makurdi Benue State located between $7^0$45'N and $8^0$37'E during 2019 cropping season to evaluate the effect of mineral and Organo-mineral fertilization on growth and yield of sweet potato (*Ipomea batata* {L} Lam). The fertilizer sources used as treatments were: NPK20:10:10 (100, 200 and 300 kg/ha), Poultry manure (2, 5 and 8t/ha), Fertiplus (2, 5 and 8t/ha) and control. The treatments were laid out in a Randomized Complete block Design (RCBD) and replicated three times. Vines of sweet potato was sourced from National Root Crops Research Institute Umudike, cut into 25 cm long and planted at a spacing of 0.3 m (100 cm x 30 cm) inter-row and intra-row respectively which gave a plant population of 33,333 plants per hectare. The growth parameters of sweet potato were significantly increased (vine length, plant girth, number of leaves, leaf width) over the control. The longest vine length (153.30 cm) at 12 WAP was obtained from poultry NPK 300 kg/ha and the least from the control (11.80 cm) at 4 WAP. The longest leaf length (12.27 cm) was obtained from Fertiplus 8t/ha at 12 WAP and the least (6.00 cm) from the control at 4 WAP. The broadest leaf width (10.80 cm) was obtained from poultry 8t/ha at 6 WAP and the least (5.27 cm) from the control at WAP. The highest yield (48.67) in terms of number of marketable roots was obtained from poultry 5t/ha and the least (18.67) from the control. The highest weight of marketable root 18.70 t/ha was obtained from poultry manure 5t/ha and the least 2.97 t/ha from the control. Application of 5t/ha of poultry manure is recommended for soil fertility improvement and root yield of sweet potato in the study area.
Keywords: Organo-mineral, Fertilization, Sweet Potato, Southern Guinea Savanna
DOI: 10.7176/JBAH/11-12-02
Publication date: June 30th 2021

1. Introduction

As population increases geometrically with the current world population of over 7.5billion as at April, 2019 (UN population 2019), there must be substantial increase in food production in order to provide adequate nutrition for the 8.5 billion people projected by the year 2030 (UN population, 2019).

Soil nutrient depletion is one of the most serious problems currently affecting agricultural productivity in developing countries of the world, including Nigeria. Because Agriculture is a soil-based industry that mines nutrients from the soil on continuous basis, effective and efficient approaches to slowing that removal and returning nutrients to the soil is required. The intensification of cultivation with little or no fertility management has been one of the critical factors militating against productivity increase to meet the food and fibre needs of a rapidly growing population, thus, endangering food security (Senjobi, 2007).

According to Batiano and Makwunye, (1991); Ajilore,(2008), continuous cropping reduces soil organic matter, causes significant acidification and yield reduction. Therefore, there is need for adequate fertilization or manuring in order to sustain soil productivity for optimum growth and yield of planted crops to ensure food security for the ever increasing population. Organo-mineral fertilizer is a low-input technology using organic manure to supplement inorganic fertilizer use. It is an integrated management strategy, that is of paramount importance to reducing the cost and quantity of soil mineral input, maximizing yield and, conserving our soils. They combine the attributes of both organic and inorganic fertilizers (Ayeni *et al*., 2008). Studies by Adoeye *et al*., (2008); Ojeniyi *et al.,* (2009), have shown positive responses of maize and pepper to organo-mineral fertilizer. Similarly, Makinde *et al*., (2010) recorded that, the use of organo-mineral fertilizers enhanced better growth in *Amaranthus cruentus*.

Sweet potato production is coming up gradually as reported by Nwanko *et al*. (2018). Farmers have seen its ability to thrive in low fertile lands (Nwanko *et al.*, 2018) and its short growth circle which last between 3-5 months after planting when compared to yam, cassava, cocoyam which takes up to 8–12 months to mature. It is an important staple food crop in many countries of the tropical region with both domestic and industrial uses. It is an emerging food security crop in Nigeria and is cultivated in all agro-ecological zones of the country.

However, Sweet potato yield in Nigeria is still low due to declining soil fertility and mismanagement of plant nutrients, which necessitated the needs for fertilizer application. According to Chude *et al.,* 2012, sweet potato needs about 44kg -130kg/ha of Nitrogen; 12kg – 35kg/ha of phosphorus and 20kg – 75kg/ha of Potassium

depending on the class of the soil. But the challenge farmers are facing is that of how much of what to be applied to supply the desired nutrients. This is because what farmers apply in root and tuber crops is mixed forms of fertilizers since they cannot afford buying single fertilizers which can easily be measured.

Due to paucity of information on the use of fertilizers for sweet potato production in Benue State, this study is designed to evaluate the effects of these selected fertilizers on the performance of sweet potato in Makurdi, Benue State, Southern Guinea Savannah of Nigeria.

2. Materials and Methods

2.1Study site

The experiment was conducted during the cropping season of 2019 at the Experimental Farm of the University of Agriculture Makurdi Benue State located between $7^0$45'N and $8^0$37'E

2.2 Design of experiment

This was randomized complete block design (RCBD) consisting of 10 Treatments. The fertilizer sources used as treatments were: NPK20:10:10 (100, 200 and 300 kg/ha), Poultry manure (2, 5 and 8t/ha), Fertiplus (2, 5 and 8t/ha) and control replicated three times.

2.3 Land preparation and planting

The fields were cleared manually and debris removed from the field. Four (4) ridges of 3 meters long were constructed using big hoe. Each plot measured 3m x 4m =12m^2 with 1m used as alleyways used to separate between plots and between replications. Vines of sweet potato TIS-8164 sourced from National Root Crops Research Institute Umudike were cut into 25cm long pieces with at least three nodes per plant. The vine cuttings were planted at an angle to the ground (Parwada *et al*., 2011) with at least two third of the vine buried under the soil for easy sprouting and establishment. Supplying was done at 2 weeks after planting (WAP).

Planting was done at a spacing of 1m by 0.3m (100cm x 30cm) inter-row and intra-row respectively which gave a plant population of 33,333 plants per hectare.

2.4 Fertilizer application

Poultry manure sourced from a deep litter system was cured and applied 2 weeks before planting. Application was done by properly incorporating the poultry manure into the soil to allow for easy decomposition and mineralization. NPK 20:10:10 and fertiplus were applied 2 weeks after planting (WAP) using side placement method. The openings were properly covered after application.

2.5 Data collection

2.5.1 Soil: A composite sample was collected at the 0 – 15 cm depth from random points on the field before treatments application. After harvest, soil samples were also taken from each plot based on the treatment applied. The soil samples were air dried and sieved with a 2mm sieve and was subjected to standard laboratory analysis as outlined by Udo *et al*. (2009).

2.5.2 Plant: Five plants were randomly tagged in each net plot from where growth parameters were taken; number of leaves, vine length, vigour, girth, leaf length and leaf width at 4, 6,8,10 and, 12 WAP respectively. Yield parameters were taken at harvest; number of marketable roots, weight of marketable roots, number of non-marketable roots, weight of non-marketable roots, weight of top biomass, total root weight.

2.6 Analysis

The crop data generated from the field was subjected to Analysis of Variance (ANOVA) using GENSTAT 17 version, while significant means was separated using Duncan's New Multiple Range Test at 5% probability level

3. Results and Discussion

3.1 Initial Properties of Soil

The chemical properties of the soil used for the conduct of the experiment is presented in (Table 1).The soil was slightly acidic, low in OM, N, P, K, Mg, and Ca which could be attributed to continuous cultivation which resulted in the removal and loss of basic cations from the soil (Rafi, 1996; Law-Ogbomo and Egharevba, (2009)

3.2 Effect of Fertilizer Treatment on Growth of Sweet potato

Observation on plant vine length and number of leaves (Table 2). The result showed a significant difference ($p<0.05$) with increase in vine length and number of leaves with increased levels of fertilizer for all the fertilizer types. 300kg/ha gave the highest vine length of 25cm at 4WAP, 92.13cm at 8WAP, 115.67cm at 10WAP and 153.3cm at 12WAP, for number of leaves 8t/ha of PM gave the highest mean value for number of leaves 14.87 at 4WAP and 34.06 at 12 WAP while control gave the least mean values for all the sampled weeks. (Table 3)

shows the effect of fertilizer on leaf length with 300 kg/ha having the highest leaf length of 9.87cm at 4WAP, 12.33cm at 6WAP, and 12.67 cm at 8WAP. For leaf width (Table 3), the result showed significant difference for all the treatments, Poultry manure at 8 t/ha (10.53 cm) and 5 t/ha (10.40 cm) gave the highest means followed by NPK at 300 kg/ha (10.33 cm) and least by the control (8.80 cm). Plant girth (Table 4) Poultry manure at 8t/ha gave the highest plant girth at all the sampled weeks except at 6 WAP where 300kg/ha gave the highest mean value of 0.75cm. The response of Sweet potato to these sources of fertilization supports the work of Singh and Raghar, (2000); Djilani and Senoussi (2013) that fertilizers either organic or inorganic increased vine length with increased level of fertilization. Also Havlin *et al.,* (2005) reported that an adequate supply of nutrients to plant release N which is associated with vegetative growth and yield.

3.3 Effect of Fertilizer Treatment on Yield and Yield Parameters of Sweet potato

Observation on yield and yield parameters of Sweet potato (Table 5) All the parameters measured at harvest were all influenced significantly ($p<0.05$) by the application of organic, mineral and organo-mineral fertilizers. 5 t/ha of poultry manure gave the highest significant mean value (48.67) for number of marketable root (NMR) while control had least value of 8.67. For weight of marketable root (WMR) poultry manure applied at 5 t/ha had the highest mean weight of 18.70kg/plot (15.58t/ha) while control had a least mean weight value of 2.97 kg/plot (2.48 t/ha). The number of non-marketable root (NNMR) presented in (Table 5) shows that control has the highest mean value of 49.33; poultry manure 5t/ha has the least mean value of 10.00. The values obtained from 8t/ha poultry manure (26.67), NPK 300 Kg/ha (21.67) and NPK 200 Kg/ha (24.33) are statistically similar. For WNMR, NPK 100 kg/ha had the highest mean values of 1.07 t/ha; Control has 0.90 t/ha the least value of 0.27 t/ha was obtained from poultry manure 5 t/ha and OMF 8 t/ha. Weight of top biomass (Table 5) was significantly responded positively to varying rates of fertilizer types used. The highest weights were recorded in plots receiving 8 t/ha of poultry manure 49.00 kg/plot (40.83t/ha) and the least from the control 18.43 kg/plot (15.36 t/ha).

The positive response of yield parameters of potato in this study to organic, mineral and organo-mineral fertilizers supports the findings of Havlin *et al.,* (2005) who reported that an adequate supply of nutrients to plant influence increased yield. The work of Agbede and Adekiya (2011) also affirmed that yield of sweet potato was influenced by poultry manure and also improve the soil fertility status by activating the soil microbial biomass

4. Conclusion

The results of this study showed that the application of organic, mineral and organo-mineral fertilizers (Fertiplus) are generally beneficial to the performance of sweet potato. However, application of 5 t/ha poultry manure gave the highest yield of 18.70 t/ha, while 8 t/ha poultry manure gave highest weight of biomass. For resource poor farmers' benefit and soil fertility improvement 5 t/ha poultry manure will be appropriate to be used at this study area.

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Table 1: Initial physical and chemical properties of soil of the study area

Soil Parameters	Value
Sand (%)	80
Silt (%)	5.4
Clay (%)	14.6
Textural class	Sandy loam
pH	6.43
O.C (%)	0.74
O.M (%)	1.28
N (%)	0.098
P ($mgkg^{-1}$)	3.00
K ($cmolkg^{-1}$)	0.21
Ca ($cmolkg^{-1}$)	2.70
Mg ($cmolkg^{-1}$)	2.40
Na ($cmolkg^{-1}$)	0.18
E.B ($cmolkg^{-1}$)	5.49
E.A ($cmolkg^{-1}$)	1.00
CEC ($cmolkg^{-1}$)	6.94
B.S %	84.59

Table 2 Effect of fertilizer on vine length (VL) and number of leaves (NOL) of sweet potato.

Treatment	VL 4WAP		VL 6WAP		VL 8WAP		VL 10WAP		VL 12WAP	
	VL cm	NOL	VL cm	NOL	VL cm	NOL	VL cm	NOL	VL cm	NOL
CONTROL	11.80e	5.68e	30.00f	17.87f	42.73f	25.80g	71.67g	25.93f	97.70h	23.27f
NPK 100Kg/ha	17.67ed	9.00d	40.20de	20.20e	64.73cde	27.20fg	85.67ef	27.20f	114.10fg	24.60f
NPK 200Kg/ha	19.40c	10.47cd	47.60c	24.87d	74.53bc	30.00cde	100.07cd	30.40cde	128.31de	28.07de
NPK 300Kg/ha	25.00a	11.00bcd	55.20b	25.27d	92.13a	30.33cd	115.67a	31.13bcd	153.30a	28.13de
PM 2 t/ha	14.40de	10.07cd	37.73e	24.40d	58.40de	29.13de	94.13de	29.80de	116.90f	26.80e
PM 5 t/ha	20.33bc	14.13a	49.40c	29.27ab	78.73b	33.80a	105.47bc	34.80a	136.81bc	32.87ab
PM 8 t/ha	23.80ab	14.87a	62.13a	30.53a	82.53ab	35.07a	112.27ab	35.67a	142.70b	34.60a
OMF 2 t/ha	14.17de	9.67cd	35.60e	21.80e	53.47ef	28.53ef	81.20f	28.93c	106.62g	27.33e
OMF 5 t/ha	18.33c	11.80bc	18.33c	26.07cd	70.00bcd	31.33bc	96.60cd	32.00bc	122.51ef	29.53cd
OMF 8 t/ha	18.53c	12.77ab	18.53c	28.00bc	72.33bc	32.20b	103.93bc	32.73b	132.22cd	31.00bc

Values with the same letter within the same column are not significant using DNMRT ($P<0.05$) NPK=20-10-10, PM = poultry manure, OMF = fertiplus. VL= Vine length.

Table 3. Effect of fertilizer on leaf length (LL) and Leaf width (LW) of sweet potato.

Treatment	4 WAP (cm)		6 WAP (cm)		8 WAP (cm)		10WAP (cm)		12 WAP (cm)	
	LL	LW	LL	LW	LL	LW	LL	LW	LL	LW
NPK 0 Kg/ha	6.00f	5.27f	8.60f	7.67g	9.20f	7.87f	8.67e	7.63g	8.27e	6.13f
NPK 100 Kg/ha	6.67e	6.27cd	9.33ef	8.33fg	10.27e	8.93de	9.20de	8.27f	8.47de	6.13f
NPK 200 Kg/ha	9.61a	6.80bc	11.67ab	9.27bcde	11087b	9.87bc	9.53cde	8.73def	8.93d	7.00c
NPK 300 Kg/ha	9.87a	7.40b	12.33a	9.70bc	12.67a	10.07b	9.80cd	9.53bc	9.07d	7.20de
PM 2 t/ha	7.00de	6.07de	10.07de	8.93def	10.60de	8.47ef	9.80cd	8.47ef	9.73c	8.07abc
PM 5 t/ha	8.73b	8.53a	12.40a	10.00a	11.53bc	10.40ab	10.00bcd	10.00a	11.60a	8.53ab
PM 8 t/ha	7.73c	8.93a	11.13bc	10.80a	11.67b	10.93a	10.40bc	9.80ab	10.27bc	8.67a
OMF 2 t/ha	7.27cde	5.47ef	9.80de	8.61ef	10.33e	9.33cd	10.40bc	8.60ef	10.67b	6.20f
OMF 5 t/ha	7.27cde	6.40cd	10.47cd	9.13cde	11.00cd	9.87bc	10.93b	8.87de	10.73c	7.60cde
OMF 8 t/ha	7.43cd	6.73cd	10.20de	9.60bcd	11.07cd	10.27b	12.27a	9.13cd	10.07bc	7.87bcd

Values with the same letter within the same column are not significant using DNMRT (P<0.05)NPK=20-10-10, PM = poultry manure, OMF = fertiplus and LL= Leaf Length.

Table 4. Effect of fertilizer on girth (PG) of sweet potato

Treatment	4 WAP PG (cm)	6 WAP PG (cm)	8 WAP PG (cm)	10 WAP PG (cm)	12 WAP PG (cm)
CONTROL	0.39e	0.37c	0.56b	0.72b	1.05f
NPK 100 Kg/ha	0.47d	0.55b	0.58b	0.82b	1.08ef
200 Kg/ha	0.53c	0.65ab	0.64b	1.01b	1.22cde
300 Kg/ha	0.61b	0.75a	0.73b	1.13b	1.33bc
PM 2 t/ha	0.46d	0.57ab	0.62b	0.96b	1.19cdef
PM 5 t/ha	0.49cd	0.65ab	0.70b	1.08b	1.29c
PM 8 t/ha	0.65a	0.69ab	2.95a	1.88a	1.69a
OMF 2 t/ha	0.42e	0.59ab	0.61b	0.93b	1.11def
OMF 5 t/ha	0.49cd	0.63ab	0.67b	1.05b	1.26cd
OMF 8 t/ha	0.52c	0.68ab	0.81b	1.16b	1.45b

Values with the same letter within the same column are not significant using DNMRT (P<0.05)
NPK=20-10-10, PM = poultry manure, OMF = fertiplus and PG= Plant girth.

Table 5. Effect of fertilizer on yield and yield parameters of sweet potato

Treatment	NMR	NNMR	WMR (t/ha)	WNMR (t/ha)	WTB (t/ha)
CONTROL	18.67g	49.33a	2.97b	0.90ab	18.43g
NPK 100 Kg/ha	20.67fg	39.33b	3.93b	1.07a	27.07de
200 Kg/ha	28.67de	24.33cde	6.27b	0.73bc	28.87cd
300 Kg/ha	37.33bc	21.67de	7.50b	0.63cd	33.23bc
PM 2 t/ha	27.67de	18.33def	5.20b	0.47de	23.57ef
PM 5 t/ha	48.67a	10.00f	18.70a	0.27e	44.57a
PM 8 t/ha	32.67cd	26.67cd	8.27b	0.77bc	49.00a
OMF 2 t/ha	25.00ef	32.33bc	4.60b	0.87ab	21.00fg
OMF 5 t/ha	30.00de	16.67ef	5.77b	0.43de	27.60de
OMF 8 t/ha	41.33b	12.33f	9.07b	0.27e	37.37b

Values with the same letter within the same column are not significant using DNMRT ($P<0.05$) NPK=20-10-10, PM = poultry manure, OMF = fertiplus, NMR= number of marketable roots, NNMR= number of non-marketable roots, WMR = weight of marketable roots, WNMR = weight of non-marketable roots, WTB = weight of top biomass