INFLUENCE OF ORGANIC FERTILIZER RATE AND TYPE ON THE GROWTH AND YIELD OF SWEETPOTATO (*IPOMOEA BATATAS* (L.) LAM) VARIETIES IN THE SOUTHERN GUINEA SAVANNAH OF NIGERIA

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ABSTRACT

A field trial was carried out during the rainy seasons of 2011 and 2012 at Akwanga in the southern Guinea savannah of Nigeria (latitude 08^0 54'N, longitude 07^0 33'E) to determine the effects of organic fertilizer rates (0, 1.5, 3.0 and 4.5t ha^{-1}) and different types of fertilizers (fertiplus, nomau and rootslizer) on the growth and yield of two sweetpotato (TIS 2535 op 1.13 and Ex-Igbariam) varieties. Split-split plot design was used as design for the experiment with variety in the main plot, fertilizer in the sub-plot and fertilizer rate in the sub-sub plot, replicated three times. The results obtained showed that variety TIS 2535 op 1.13 had significantly ($P \leq 0.05$) longer trails with higher number of vines, higher root diameter and yield (t ha^{-1}) than EX-Igbariam. Application of fertiplus and rootslizer was observed to produce significantly ($P \leq 0.05$) longer trails, more vines, higher root diameter and root yield than nomau. Even though, rootslizer statistically ($P \leq 0.05$) produced higher root yield in 2011 than fertiplus. Application of 4.5 t ha^{-1} produced significantly ($P \leq 0.05$) longer trials with more vines, root diameter, fresh root weight and yield than the other rates used. From the forgoing, TIS 2535 op 1.13 had the potential for increased yield per unit area with the application of fertiplus at the rate of 4.5 t ha^{-1}.

Keywords: Effect, Growth, Organic fertilizer type and rate, Sweetpotato, Yield.

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INTRODUCTION

Sweetpotato (Ipomoea batatas [L.] Lam), a member of the Convolvulaceae family, originated in the western hemisphere. Botanically, the underground part is classified as a storage root rather than a tuber as in the case of "Irish" potato (*Solanum tuberosum* L). Sweetpotato is one word because the crop is distinctly different from potato and yam [North CVP guide, 2003]. Sweetpotato which is now basically a crop of Asia, accounts for about 93% of world production, sixth most important food crop in the world and the third most important root crop in Africa after yam and cassava [FAO, 2000]. In an earlier survey in 1992 by the presidential task force on alternative formulation of livestock feed, it was reported that sweetpotato is grown in all parts of Nigeria, with leading producing areas; Kaduna, Bauchi, Sokoto, Benue and Anambra [Tewe, 2003]. Besides simple starches, sweetpotato is rich in complex carbohydrates, dietary fibre, beta-carotene, protein, iron, calcium, vitamin C and B_6. Recently, it was revealed that sweetpotato helps to stabilize blood sugar levels and lower insulin resistance [Wikipedia, 2009].

Government involvement in fertilizer distribution in Nigeria has made the role of organic matter as a source of plant nutrient, more desirable [Olusola, 2009]. Similarly, increase in its price, coupled with unreliable availability to farmers has made the assessment of the role of organic fertilizers in Nigerian agriculture more imperative. (i) The use of low yielding sweetpotato varieties in Nigeria has been identified as a serious setback to increased sweetpotato production. Subsidy on fertilizer by the federal and state governments of Nigeria has made availability of the commodity to peasant farmers' virtually nonexistent due to hijack by middlemen and bureaucrats. (ii) However, with the recent initiative by National Root Crop Research Institute on new varietal release, yields are expected to increase from 2-3 t/ha to 30-40 t/ha [FAO, 2008; http.//www.nrcri.gov.ng/pages/sweetpotato.html (2012)]. Agronomic practices like the use of organic fertilizer which replaces trace elements, improves biodiversity and long-term productivity of soil, and also influences sweetpotato production as against the unavailable and costly mineral fertilizers. The good understanding of organic fertilizer has shown potentials for increased yield in sweetpotato with reduction in production cost. Negative effects of inorganic fertilizer on the environment [Rosen and Horgan, 2010] and soil properties in addition to its scarcity and cost tend to discourage farmers from producing the crop. Higher or lower application rates of organic fertilizers in sweetpotato may also affect its yield tremendously.

MATERIALS AND METHODS

A field experiment was conducted during the wet seasons of 2011 and 2012 at Nasarawa Agricultural Development Programme (N.A.D.P) seed farm, Akwanga (lat 8^0 54'N and long $8^0$22'E) in the southern Guinea savannah ecological zone of Nigeria. Akwanga has an average rainfall of about 1400mm per annum, mostly distributed between the months of March and November with mean temperatures ranging from 21- 40^0C. The treatments consist of two improved sweetpotato varieties (TIS 2535 op 1.13 and EX-Igbariam), three organic fertilizers (fertiplus, nomau and rootslizer) and four different application rates (0 t/ha, 1.5 t/ha, 3.0 t/ha and 4.5 t/ha). The factorial combination was laid out in a split-split plot design with variety in the main plot, fertilizer in the sub-plot and fertilizer rate in the sub-sub plot, all replicated three times. Soil samples were taken randomly prior to land preparation at the depth of 0-30cm and analysed for texture and nutrient levels (Table 1).

Table 1: Physico-chemical properties of the soil at both the nursery and field experimental site taken at 0-30cm soil depth.

	Nursery		Field	
Soil characteristics	2011	2012	2011	2012
Physical composition (%)				
Sand	79.60	79.60	70.01	69.52
Silt	10.00	10.00	14.23	14.56
Clay	10.40	10.40	15.76	15.92
Texture	Sandy	Sandy	Sandy loan	Sandy loan
Chemical composition				
Soil PH (1:2.5 H_2O)	5.15	5.75	6.68	6.65
Organic carbon	6.45	6.45	2.13	2.11
Total N (gkg^{-1})	2.80	2.80	0.99	0.94
Available P (ppm)	9.51	9.51	7.01	6.93
CEC (meq/100g soil)	5.44	5.44	5.34	5.33
Exchangeable bases (Meq/100g soil)				
Ca^{2+}	3.03	3.03	2.34	2.68
Mg^{2+}	0.88	0.88	0.70	0.84
K^+	0.70	0.70	0.68	0.53
Na^+	0.13	0.13	0.16	0.14

The field was then cleared, ploughed and marked into plots. The main plot size was 42.5m x 20.5m; sub-plot size was 42.5m x 2.5m while, sub-sub plot size was 3m x 2.5m with net plot size of 1m x 2.5m. A distance of 0.5m between plots and 1.5m between varieties was adopted while 1.0m was allowed between replications.

A nursery flat seedbed of 2m x 1m ($2m^2$) was constructed on a sandy soil. A cotton gin waste of $32kg/2m^2$ was laid uniformly and covered lightly to a thickness of 5cm soil where 100-200g conditioned roots were placed 9-10cm apart uniformly across the width and length of the bed. Another layer of 2.5-5.0cm soil was spread lightly and evenly to cover the root bed for the period

4-6weeks to allow it develop strong vines before transplanted to the field. However, a hose of plastic sheets was inserted at each corner of seedbed to form tunnels for easy irrigation of water.

The organic fertilizers were weighed equivalent to 0 t/ha, 1.5 t/ha, 3.0 t/ha and 4.5 t/ha, and applied as basal dose on the ridges and at a depth of 5cm by side placement method, one week before transplanting. Sprouts from the apical vine cuttings that are most vigorous and healthy were taken from the nursery bed and cut to sizes of 3-4 nodes and transplanted at the ridge crest spaced at 25cmbetween seedlings with 100cm between ridges. Weeding was carried out manually as at when due. There was no incidence of pests and diseases, hence pesticides were not utilized. Harvesting was done manually with small hoe at 16 WAT. Ten plants were randomly selected and tagged from the net plot for the assessment of growth characters like vine length and number of vines. Yield and yield related characters taken at harvest were number of roots per plant, root fresh weight, root diameter and root yield were also assessed from the tagged plant per net plot.

The data obtained were subjected to analysis of variance using Genstat version 7.2. [9] Was employed to separate means of treatments using MSTAT-C (Michigan State University. Version 2.10, USA).

RESULTS AND DISCUSSION

Vine length (cm)

The effect of variety, organic fertilizer type and its rate of application on vine length of sweetpotato are presented in table 2. Throughout the sampling dates, the two varieties differed significantly ($P \leq 0.05$) on vine length. Variety TIS 2535 op 1.13 was observed to consistently produce longer vines than Ex-Igbariam. Among the organic fertilizers, there was also significant difference on vine length throughout the sampling dates except at 14WAT in 2011. Application of fertiplus and rootslizer produced consistently longer vines than nomau. At the different application rates, application of 3.0 and 4.5 t/ha had significantly ($P \leq 0.05$) longer vines than that of 1.5 t/ha and the control.

Table 2: Effect of Variety, Organic Fertilizer Type and Fertilizer Application Rate on Vine Length of Sweetpotato Grown During 2011 and 2012 Rainy Seasons

	Vine length (cm) WAT -2011				Vine length (cm) WAT -2012			
Treatment	8	10	12	14	8	10	12	14
Variety								
TIS 2535 op 1.13	91.6[a]	159.2[a]	239.9[a]	229.0[a]	86.92[a]	158.2[a]	232.9[a]	318.1[a]
Ex-Igbariam	67.6[b]	101.2[b]	140.1[b]	122.0[b]	69.4[b]	91.8[b]	115.1[b]	140.3[b]
SE (±)	4.19	5.32	9.21	14.9	3.25	5.99	9.42	11.88
Organic Fertilizer								
Fertiplus	85.1[a]	145.6[a]	210.9[a]	186.0	77.9	138.4	187.1	240.6

Nomau	67.5[b]	102.2[b]	152.5[b]	154.0	79.5	117.6	166.3	219.0
Rootslizer	86.2[b]	142.8[a]	206.6[a]	186.0	77.2	119.0	168.6	227.9
SE (±)	5.13	6.52	11.28	18.2	3.98	7.34	4.53	14.55
Application Rate (t/ha)								
Control	59.1[c]	82.9[d]	117.2[c]	135.0[b]	67.4[b]	92.4[b]	117.9[c]	146.5[c]
1.5	73.9[bc]	112.6[c]	158.3[b]	158.0[b]	80.3[ab]	122.3[a]	165.1[b]	222.3[b]
3.0	86.8[ab]	149.9[b]	224.1[a]	218.0[a]	80.7[ab]	142.6[a]	193.8[ab]	250.3[ab]
4.5	98.6[a]	175.3[a]	260.1[a]	190.0[b]	84.2[a]	142.6[a]	219.2[a]	297.0[a]
SE (±)	5.93	7.52	13.03	21.0	4.60	8.47	13.32	16.80
Interaction								
R x Var	NS	NS	NS	NS	NS	NS	NS	*
F x Var	NS	*	NS	NS	NS	NS	NS	NS
F x R	NS	NS	NS	NS	NS	NS	NS	NS
F x R x Var	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column of treatment followed by unlike letter(s) are significantly different using DMRT at 5% level of significance. WAT = Weeks after transplanting; NS = Not significant * Significant at 5% probability level.

Interaction between organic fertilizer and its application rate at 10WAT (Figure 1) indicated that irrespective of the organic fertilizer type used, control plots had consistently shorter vines when compared to the other rates used. On the other hand, where fertiplus, nomau and rootslizer were considered with application of 1.5, 3.0 and 4.5t/ha, a V shape rating was formed with nomau in the middle, indicating longer vines under fertiplus and rootslizer application. Moreover, application of 4.5t/ha had longer vines over 3.0 and 1.5 t/ha when fertiplus and rootslizer were used.

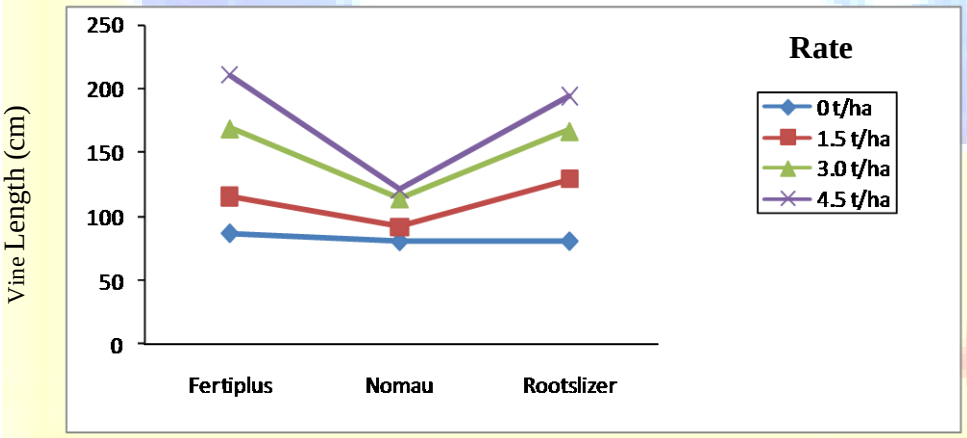


Figure 1: Interaction between Organic Fertilizer Type and Fertilizer Application Rate at 10 WAT on Vine Length of Sweetpotato Grown During the 2011 Rainy Season

Number of vin

Effect of variety, organic fertilizer type and its fertilizer rate on number of vines is presented in table 3. TIS 2535 op 1.13 was observed to be superior on number of vines per plant significantly ($P \leq 0.05$) than Ex-Igbariam. Except at 8 and 10 WAT in 2011 and at 8WAT in 2012, significant

(P≤ 0.05) difference was also observed among the different organic fertilizer used, fertiplus and rootslizer had consistently higher number of vines than nomau.

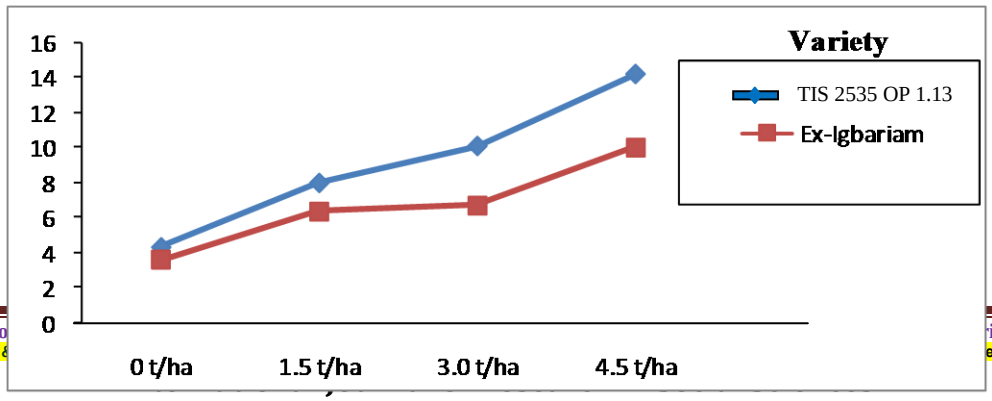
At the different fertilizer application rates, application of 4.5 t/ha consistently gave higher number of vines than the other rates used. On the other hand, control plots also had consistently lower number of vines than the other rates used.

Table 3: Effect of Variety, Organic Fertilizer Type and Fertilizer Application Rate on Number of Vines per Plant of Sweetpotato Grown During 2011 and 2012 Rainy Seasons

	Number of Vines Per Plant WAT- 2011				Number of Vines Per Plant WAT-2012			
Treatment	8	10	12	14	8	10	12	14
Variety								
TIS 2535 op 1.13	2.19^{a}	4.47^{a}	8.17^{a}	9.17^{a}	2.72	4.61^{a}	6.47^{a}	9.06^{a}
Ex-Igbariam	1.83^{b}	3.08^{b}	5.67^{b}	6.64^{b}	2.55	3.69^{b}	5.06^{b}	7.36^{b}
SE (±)	0.096	0.195	0.838	0.345	0.132	0.203	0.227	0.530
Organic Fertilizer								
Fertiplus	2.13	5.75	4.21^{a}	8.54^{a}	2.87	4.58^{a}	6.46^{a}	9.79^{a}
Nomau	1.88	6.29	3.17^{b}	6.71^{b}	2.41	3.79^{c}	4.96^{b}	7.33^{c}
Rootslizer	2.04	5.71	3.96^{a}	8.46^{a}	2.62	4.08^{ab}	5.88^{a}	8.50^{b}
SE (±)	0.117	1.027	0.239	0.422	0.162	0.248	0.279	0.649
Application Rate (t/ha)								
Control	1.22^{c}	2.28^{d}	2.67^{b}	3.94^{c}	1.77^{c}	2.50^{c}	2.94^{d}	5.50^{b}
1.5	1.78^{bc}	3.28^{c}	4.83^{ab}	7.17^{b}	2.44^{b}	4.33^{b}	5.50^{c}	8.33^{a}
3.0	1.06^{b}	4.11^{b}	8.22^{a}	8.39^{b}	2.72^{b}	4.17^{b}	6.50^{b}	9.61^{a}
4.5	3.00^{a}	5.44^{a}	7.94^{a}	12.11^{a}	3.61^{a}	5.61^{a}	8.11^{a}	9.39^{a}
SE (±)	0.136	0.276	1.185	0.488	0.187	0.287	0.322	0.749
Interaction								
R x Var	NS	NS	NS	*	NS	NS	NS	NS
F x Var	NS	NS	NS	NS	*	*	NS	NS
F x R	NS	NS	NS	NS	NS	NS	NS	NS
F x R x Var	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column of treatment followed by unlike letter(s) are significantly different using DMRT at 5% level of significance. WAT = Weeks after transplanting; NS = Not significant * Significant at 5% probability level

Figure 3 indicated a partial interaction between application rate and variety at 14 WAT on number of vines in 2011. The figure shows that application of 4.5 t/ha to the two varieties consistently produces higher number of vines than the other application rates used. Control plots on the other hand, was the least in production of vines per plant. The figure also indicated that irrespective of the different application rates used, performance of Ex-Igbariam on number of vines was consistently lower than that of TIS 2535 op 1.13.



Fertilizer Application Rate

Figure 2: Interaction between Fertilizer Application Rate and Variety at 14 WAT on Number of Vines per Plant of Sweetpotato Grown During 2011 Rainy Season

The results of this study revealed that longer vines observed from variety TIS 2535 op 1.13 over Ex-Igbariam, may not be unrelated with the inherent genetic character of the variety which produced longer vines (178.6cm) than Ex- Igbariam (97.26cm). This conforms to the findings of [Hossain, 1995] and [Jahan *et al*., 2009] that vine length in sweetpotato ranged from 87.72 – 176.73cm. The use of fertiplus and rootslizer led to the production of longer vines as against nomau fertilizer. Higher N.P.K nutrient content of 4 -3-3 and 3-6-3 for fertiplus and rootslizer respectively might have led to the better performance of the two fertilizers over nomau.

The positive performance of this fertilizer could also be attributed to low level of cobalt (2mg/kg) contained in the fertilizers. [Nadia and Ogbelu, 2008] corroborated with the present finding that using cobalt level of 10ppm increased vine length of sweetpotato. Variation in rainfall which results into higher (1595mm) amount of rainfall might have led to shorter vine production. This result agrees with that of [Anoike and Ogbelu, 2003] who reported that high amount of rainfall is not favourable for optimum plant growth. And the primary humic acid content that releases the mineral present in the ground of the different fertilizers could have also led to the performance of the different fertilizers. Application of fertilizer up to 4.5t/ha consistently led to production of longer vines than the control (Table 3). The longer vines produced due to application of the fertilizers could be attributed to higher amounts of 65% and 35% organic matter in fertiplus and rootslizer respectively for growth of the crop. [Micheal, 2008] Working with cow dung and poultry manure corroborates the present work on garden egg.

Results of interaction studies (Figure 2) confirmed the positive contribution of fertiplus and rootslizer on plant growth of sweetpotato. Similarly, positive growth could be observed where the different fertilizers were applied as against where no fertilizer was applied at all, indicating that irrespective of the three different fertilizers used, very low growth of the crop is obtained when it is grown without fertilizer application This result agrees with that of [Ali *et al*., 2009] working on sweetpotato that, organic fertilizer increase vine length compared to control. Also, TIS 2535 op 1.13 responded more to the different fertilizer rates than Ex-Igbariam on vine length (Figure 2). Genetically, TIS 2535 op 1.13 might have fast root initiation, higher mineral absorption and sink growth over Ex-Igbariam.

Higher number of vines observed with TIS 2535 op 1.13 over Ex. Igbariam may be due to genetic factors inherent within the variety. Hence, the variation in number of vines might be due to varietal characteristic. The present result concurs with that of [Farooguue, 1973] and [Hossain,

1995] who showed that the local varieties produced higher number of vines per plant than other varieties. Use of fertiplus and rootslizer at 12 and 14 WAT in 2011 and 2012, led to production of higher number of vines than nomau. Apart from the nutritional content of the two fertilizers, the rate of release of the mineral element by the humic acid and amino acid structures contained in the different types might be responsible for the variation in performance of the different fertilizers. Variation in rainfall, rate of mineralization and decomposition of the different fertilizers could also be a reason on their performance. The present result is supported by that of [Michael, 2008] working on Garden egg that at 10 and 14 WAT, both cow dung and poultry droppings tremendously increased number of branches of the crop. Application rates of 1.5, 3.0 and 4.5 t/ha consistently led to the production of higher number of vines than the control (Table 3). The higher number of vines produced due to the higher application rates could be attributed to full nutrient mineralization and utilization of water for growth and branching in sweetpotato. The result of this work also corroborates with the recent work by [Mukhtar *et al*., 2010], working on sweetpotato that higher rate of both organic and inorganic fertilizers increases vine number in sweetpotato.

Positive response of TIS 2535 op 1.13 in interaction with fertilizer application rate when compared to Ex-Igbariam, might be because addition of nutrients encouraged growth. Organic fertilizer in forms of fertiplus, nomau and rootslizer improves soil structure, releases minerals present in the soil and improve their ability of the crop root to utilize water resources more effectively and prevents alkalisation of the agricultural land. [Mukhtar *et al*. 2010] Recently supported the present findings that the use of organic fertilizer increases growth of sweetpotato. On the other hand, TIS 2535op1.13 was observed to respond more to fertiplus and rootslizer than Ex-Igbariam. On the number of vines, the high nutritional content of fertiplus (4-3-3-65 % OM) and rootslizer (3-6-3-36% OM) showed clear manifestation of nutrient content as against nomau where its nutritional content on the bag was not clearly written. Similarly, the study indicated clear increase on number of vines where the different fertilizers were applied on TIS 2535 op1.13 as against EX-Igbariam. This shows that irrespective of the application rates used, higher number of vines was observed with fertiplus and rootslizer application than nomau.

The higher number of vines could be as result of high and balanced nutritional content of fertiplus and rootslizer. This result concurs with the findings of [Balehu, 2003] and [Micheal,

2008], working on garden egg that both cow dung and poultry droppings increases number of branches.

It could also be attributed to high content of K contained in the fertilizers [Bourke, 1977] and [Hartemink et al. 2009] reported that K fertilizer had no effect on vine yield but increased root yield and number of roots.

Number of roots per plant

Table 4 shows the effect of variety, organic fertilizer type and fertilizer application rate on number of roots per plant grown during the rainy seasons of 2011 and 2012. At harvest, root number of the two varieties where similar. Similarly, effect of fertiplus, nomau, and rootslizer on number of roots per plant was also similar statistically. The different application rates on the other hand, indicated that application of 1.5, 3.0 and 4.5 t/ha had significantly ($P \leq 0.05$) higher root number than the control in both years of the investigation and combine.

Application rates of 15, 3.0 and 4.5t/ha consistently led to higher number of roots than the control (Table 4). The higher number of roots produced due to application rate of organic fertilizer could be attributed to full mineralization, efficient utilization of water and sunlight for the manufacture of photosynthates indicating more assimilate partitioning for more root production [Micheal, 2008] working on garden egg corroborates the present work that higher rates of both cow dung and poultry dropping increases number of fruits per plant.

Table 4: Effect of Variety, Organic Fertilizer Type and Fertilizer Application Rate on Number of Roots Per Plant and Root Diameter of Sweetpotato Grown During 2011 and 2012 Rainy Seasons

	Number of Roots Per Plant			Root Diameter (cm^3)		
Treatment	2011	2012	Combined	2011	2012	Combined
Variety						
TIS 2535 op1.13	3.02	2.96	2.99	7.49^{a}	7.27^{a}	7.38^{a}
EX – Igbariam	2.82	4.61	3.71	6.53^{b}	6.04^{b}	6.29^{b}
SE(±)	0.148	1.396	0.77	0.202	0.195	0.198
Organic Fertilizer						
Fertiplus	3.11	6.05	4.58	7.25	7.10^{a}	7.18
Nomau	2.67	2.54	2.61	6.87	6.13^{b}	6.50
Rootslizer	2.99	2.77	2.88	6.92	6.73^{ab}	6.82
SE(±)	0.146	1.770	0.958	0.269	0.323	0.296
Application Rate (t/ha)						
Control	2.31^{b}	0.43^{b}	1.37^{b}	5.33^{c}	5.48^{c}	5.41^{d}
1.5	2.86^{a}	2.88^{a}	2.87^{a}	7.13^{b}	6.39^{b}	6.76^{c}
3.0	3.13^{a}	2.98^{a}	3.06^{a}	7.14^{b}	6.88^{b}	7.01^{b}
4.5	3.39^{a}	2.91^{a}	3.15^{a}	8.45^{a}	7.88^{a}	8.57^{a}
SE(±)	0.156	2.060	1.108	0.203	0.253	0.228
Interaction						
R x Var	NS	NS		NS	NS	
F x Var	NS	NS		NS	NS	

F x R	NS	NS	NS	NS
F x R x Var	NS	NS	NS	NS

Means within a column of treatment followed by unlike letter(s) are significantly different using DMRT at 5% level of significance.
WAT = Weeks after transplanting; NS = Not significant * Significant at 5% probability level.

Root diameter (cm^3)

Effect of variety, organic fertilizer type and fertilizer application rate on root diameter are presented in table 4. Variety TIS 2535 op 1.13 was observed to produce significantly ($P \leq 0.05$) larger roots than Ex-Igbariam in both years and the combine. At the different organic fertilizer sources however, only the season of 2012 showed significant difference were the use of fertiplus and rootslizer were statistically similar but fertiplus produced larger roots than nomau. At the different application rates, applying 4.5t/ha significantly ($P \leq 0.05$) produced larger roots than the rest of the treatments in the two-year study and combine. However, control plots were the least on size of roots produced.

The higher root diameter observed on variety TIS 2535 op 1.13 over Ex-Igbariam may not be unrelated to the fact that the variety Ex-Igbariam had lower root fresh weight (Table 5) and lower root number (Table 4) in both years of the study. The present result agrees with the findings of [Jahan *et al*. 2009] in terms of root size of between 3.35 – 4.36 cm^3 of sweetpotato in Bangladesh. The significant difference observed among the different fertilizers used on root diameter, indicated the positive performance of fertiplus and rootslizer in 2012 over nomau. The nutritional contents of the two fertilizers might have led the positive performance of the two fertilizers over nomau. From almost all the characters observed, fertiplus and rootslizer have excelled over nomau in performance of sweetpotato. However, little can be said on the nutrient contents of the two.

Root fresh weight (kg)

Effect of variety, organic fertilizer type and fertilizer application rate on root fresh weight of sweetpotato are presented in table 5. No significant difference was observed for the two varieties used and the different fertilizer sources. For the different application rates used however, application of 4.5 t/ha was observed to produce heavier roots than the other treatments used in the combine and 2011 except 3.0 t/ha. No significant different was observed in 2012 rainy season.

Application of 4.5t/ha consistently led to the production of larger size roots than the other treatments used, indicated that the higher the rate used, the larger the roots are obtained in sweetpotato. Application of 4.5t/ha observed in 2011 and the combine consistently led to the production of higher root fresh weight than other rates used (Table 5). This could be due to the higher amounts used which led to higher mineralization and utilization by the crop for longer period of time as the crop grows, develops and matures. [Mukhtar *et al.* 2010] Also supported the present investigation that increased root yield of sweetpotato was observed with 4.0t/ha which led to higher dry matter accumulation than other rates of organic manures.

Root Yield (t/ha)

Table 5 shows the effect of variety, organic fertilizer type and fertilizer application rate on root yield of sweetpotato. At harvest, the two varieties differed significantly ($P \leq 0.05$) on root yield where TIS 2535 op 1.13 was observed to be superior over Ex-Igbariam in the two year of study and combine. On the other hand, application of fertiplus was observed to produce significantly ($P \leq 0.05$) higher root yield than nomau and rootslizer at the combine even though rootslizer had statistically similar yield to fertiplus in 2011. At different application rates, application of 4.5 t/ha was observed to produce significantly ($P \leq 0.05$) higher root yield compared to the other treatments used. However, the control was the least on root yield of sweetpotato.

Interaction between organic fertilizer and variety on root yield (t/ha) is presented in figure 3. The figure indicated a partial interaction where the application of fertiplus and rootslizer had higher effect on variety TIS 2535 op 1.13 root yields. Nomau fertilizer on the other hand, had the least effect on root yield. Irrespective of the different fertilizers used, variety Ex-Igbariam was the least in yield than TIS 2535 op 1.13.

The higher yield observed in TIS 2535 op 1.13 over Ex-Igbariam, may be due to its ability to produce more photosynthates through production of more and longer vines, root size and heavier biomass. Therefore, root yield may be an inherent genetic characteristic observed in the two varieties. This result is similar to the earlier research of [Hossain and Mondal, 1994; Bahera and Jha, 1995; Jahan and Siddigue, 2001; Jahan *et al.*2009 and Ehisianya *et al.* 2011] that tuberous root yield varied significantly by the effect of variety. Fertiplus and rootslizer in the two year study and combine again led to higher root yield of sweetpotato over nomau. This positive performance could be attributed to low level cobalt (2mg/kg) contained in the fertilizer. This

result could be supported by [Nadia and Ogbelu, 2008] who reported that using cobalt level of 10ppm to the growth media significantly increased root yield of sweetpotato.

Nutritional contents of the two fertilizers might have led to the performance of the two fertilizers over nomau. The yield increase might be attributed to the high C/N ratio (9) of the two fertilizers resulting in high mineralization and mobilization of nitrogen over nomau [Hartemink, 2003] supported the present investigation that high C/N ratio in poultry litter increase yield of sweetpotato.

Application of 4.5 t/ha consistently led to production of higher root yield than the other treatments used (Table 5).High concentration of organic matter in higher rates used in the study could be responsible for these optimum root yield of 17t/ha compared to the recommended 400kg N.P.K fertilizer which can produced 12t/ha root yield of sweetpotato in Nigeria. This contradicts [Onwudike, 2010] who noted no significant difference between 4t/ha cow dung and 400kg/ha N.P.K fertilizer. However, showed that 4t/ha cow dung has higher comparative advantage over 4t/ha N.P.K fertilizer both in cost, yield returns and its effects on environment. [Ojeniyi and Adejobi, 2005] Supported the present investigation that increase in yield of sweetpotatoes is possible with the application of poultry manure at the rates of 5-12 t/ha. Similar, [Mukhtar *et al.*2010] supported the present investigation by reporting increased root yield of sweetpotatoes with 4.0t/ha which led to higher dry matter accumulation than the other rates of organic manures. [Ogunwole, 2005] Also reported that higher rates of organic fertilizer significantly improve soil aggregation, reduces soil penetration resistance and subsequently good crop growth and yield.

Table 5: Effect of Variety, Organic Fertilizer Type and Fertilizer Application Rate on Root Fresh Weight and Root Yield (t/ha) of Sweetpotato Grown During 2011 and 2012 Rainy Seasons

	Root Fresh Weight (kg)			Root Yield t/ha		
	2011	2012		2011	2012	
Treatment			Combined			Combined

Variety						
TIS 2535 op1.13	0.293	0. 88	0.586	16.62[a]	15.72[a]	16.17[a]
EX – Igbariam	0.230	0.79	0.510	10.38[b]	9.30[b]	9.84[b]
SE(±)	0.032	0.16	0.095	0.594	0.596	0.595
Organic Fertilizer						
Fertiplus	0.312	0.73	0.521	14.51[a]	14.89a	14.70[a]
Nomau	0.211	0.68	0.445	11.25[b]	10.20[c]	10.72[c]
Rootslizer	0.262	0.36	0.311	14.74[a]	12.44[b]	13.59[b]
SE(±)	0.038	0.202	0.119	0.713	0.334	0.523
Application Rate (t/ha)						
Control	0.138[c]	0.51	0.324[c]	7.51[c]	7.93[c]	7.72[c]
1.5	0.245[bc]	0.61	0.427[b]	12.98[b]	12.25[b]	12.62[b]
3.0	0.284[ab]	0.34	0.312[c]	14.87[b]	13.65[b]	14.26[b]
4.5	0.379[a]	0.90	0.639[a]	18.62[a]	16.20[a]	17.41[a]
SE(±)	0.039	0.195	0.117	0.404	0.619	0.511
Interaction						
R x Var	NS	NS		NS	NS	
F x Var	NS	NS		NS	*	
F x R	NS	NS		NS	*	
F x R x Var	NS	NS		NS	NS	

Means within a column of treatment followed by unlike letter(s) are significantly different using DMRT at 5% level of significance
WAT = Weeks after transplanting; NS = Not significant * Significant at 5% probability level.

The interaction indicated better response of TIS 2535 op 1.13 to organic fertilizer than Ex-Igbariam. Apart from adding nutrients for growth and yield of sweetpotato, organic fertilizer in forms of fertiplus and rootsilizer contains 65 and 35 organic matter percentage respectively than nomau which improves soil structure and root environment to utilize water resources more effectively. On the other hand, TIS 2535 op 1.13 responds more to fertiplus than Ex-Igbariam on root yield. Similarly, the study indicated clear increase in root yield when different fertilizers were used as against when no fertilizer was applied at all. Again irrespective of the three different fertilizers used, very low root yield was observed on sweetpotato that did not receive any fertilizer. This result agrees with the work of [Mukhtar *et al.*2010] who reported that organic fertilizer increase root yield of sweetpotato compared to control.

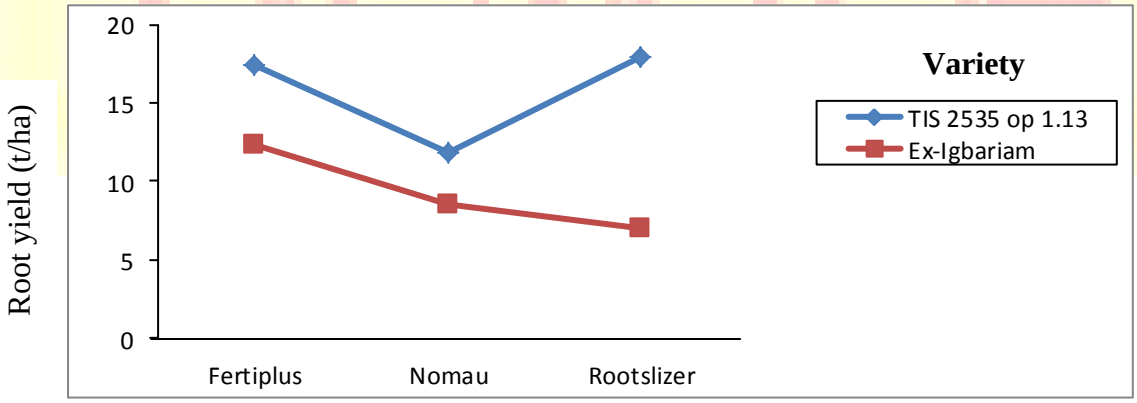
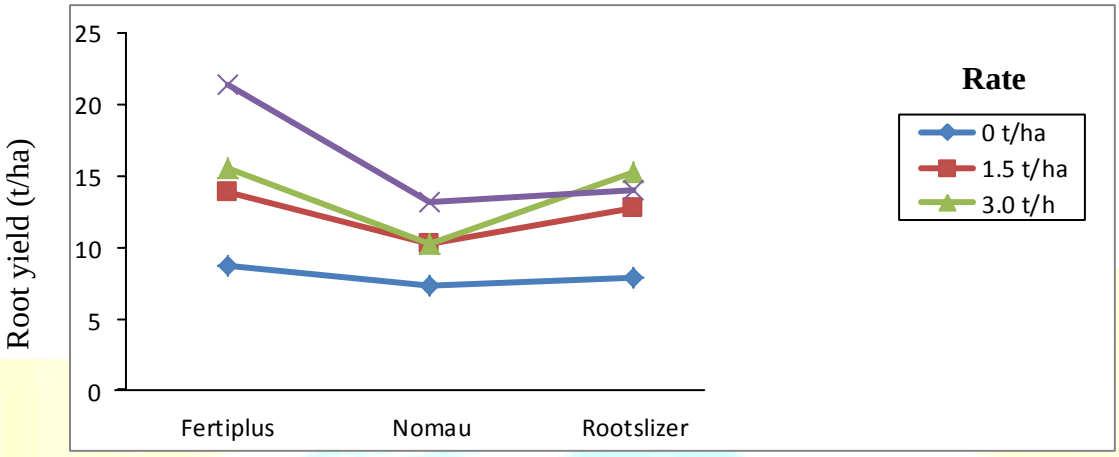


Figure 3: Interaction between Organic Fertilizer Type and Variety on Root Yield of Sweetpotato Grown During the 2012 Rainy Season



Organic Fertilizer Type

Figure 4: Interaction between Organic Fertilizer Type and Fertilizer Application Rate on Root Yield of Sweetpotato Grown During the 2012 Rainy season

CONCLUSION

From the results of this study, it showed TIS 2535 op 1.13 was superior in root yield than Ex-Igbariam even though it exhibited lower number of roots and root fresh weight. At the different fertilizer application rates, even though the usefulness of organic fertilizer to sweetpotato was observed to be imperative, higher rates as much as 4.5 t/ha may be required for optimum root yield.

RECOMENDATIONS

1. Application of either fertiplus applied at the rate of 4.5 t/ha could be recommended for optimum yield of sweetpotato.
2. Variety TIS 2535 op 1.13 could also be recommended for production under the southern guinea savannah of Nigeria.
3. This work recommends that all organic fertilizer makers in Nigeria be made to analyse all fertilizer contents and have it written on the bag. This way, farmers can adequately make decisions based on fertilizer content just like in the case of mineral fertilizer and not the trade name alone.

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