Effect Of Goat Manure On Soil Amendment And Correlation Studies For Selecting Plant Characters For Root Yield In Sweet potato

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***Abstract*— A two-year field study was conducted during the growing seasons of 2010 and 2011 in Abia State, South eastern Nigeria to evaluate the response of four improved sweet potato varieties (TIS87/0087, TIS440293, TIS 8164 and TIS 2359.op.1.13.) to four rates (0, 5, 10, and 15t/ha) of goat manure. Factorial combinations of the treatments were arranged into a randomized complete block design with four replications. Results showed that TIS 8164 responded more to goat manure than other varieties as indicated by the production of longer vines, higher number of leaves and branches per plant at all levels of application of goat manure. Also the positive significant (P<0.01) correlation (r) between total roots yield and other plant characters of sweetpotato: total number of roots (r = 0.386**), vine length (r = 0.339**), plant vigour (r = 0.689**), number of branches (r = 0.346**), leaf area (r = 0.496**) and number of leaves (r = 0.443**) indicated that the goat manure influenced the performance of the plant characters which led to high root yield of the sweetpotato varieties. The result further indicated that as the levels of application of goat manure increased, the yield and yield component parameters increased linearly indicating that 15t/ha of goat manure is not the optimum for sweetpotato production..**

***Index Terms*— sweetpotato, correlation, organic manure, yield and yield component.**

I. INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L.) Lam), a member of convolvulaceae family, is a perennial crop usually grown as an annual and a starchy staple food crop in the tropical, sub-tropical and frost-free temperate climatic zones of the world (Onwueme and Sinha, 1991). It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries (Som, 2007). The crop is known as a highly tolerant tuberous root crop to high temperatures, poor soils, floods and exhibits some resistance to pests and diseases. Sweet potato is usually planted sole or intercropped with other staples such as maize, cassava, yam or okra in West African countries where it is effective in suppressing weed growth in such fields (Eneji *et al.,* 1995).The potential of sweet potato to guarantee food security is under-estimated as its use is often limited to a substitute food in African countries. Sweetpotato is valued for its roots which are boiled, fried, baked or roasted for humans or boiled and fed to livestock as a source of energy. The roots can also be processed into flour for bread making, starch for noodles as well as used as raw material for industrial starch and alcohol (Ukom *et al*., 2009). The flour is utilized also in sweetening local beverages like *Kunu-zaki*, *burukutu*, and for fortifying baby foods and foo-foo/pounded yam in Nigeria (Tewe *et al.*, 2003). The leaves are used as vegetables in yam and cocoyam porridge and are rich in proteins, vitamins and various minerals. Sweet potato roots are rich in vitamins A, B, and C; and minerals such as K, Na, Cl, P and Ca (Onwueme & Sinha, 1991). It can therefore be a high value-addition food particularly for children and pregnant women who are more often exposed to vitamin A deficiency in sub-Saharan Africa (Degras, 2003). FAO (2012) reported that 115 countries produced 108,274,685 tonnes of sweet potato in 2010 with China producing the largest, 82,474,410 tonnes, followed by Indonesia, 2,083,623 tonnes. Far behind, but ranked second in the world after Asia, is Africa with its contribution of up to 14% of global production put at 14,441,099 tonnes in 2010 (Reaching Agents for Change (2013). Nigeria ranks second in Africa after Uganda with the production figure of 2,883,408 tonnes which has shown an increasing trend over the years (FAOSTAT, 2012). Though sweet potato crop is easy to cultivate, it is faced with some production and economic constraints. Labour costs are high in some localities; yields remain poor on account of low fertility status of the over-cropped soils, while post-harvest losses and low purchase prices have reduced production and deterred investment. Onunka *et al*., (2012) confirmed that yields of sweetpotato is presently restricted by many factors among which are low soil fertility, varietal differences, planting date, weather conditions, soil type, weed, insect and disease pressure and crop management practices among others. The crop thrives in marginal soils but improved soil fertility increases its growth and yield performance. According to Ogbalu (1999), Manure encompasses the use of chicken dropping, cow dung, wood ash and other plant and animal residues in soil and it is adopted particularly in Southeastern Nigeria in soil amendment. Use of organic fertilizer in the production of sweetpotato and other food crop is on the increase; organic manure such as poultry manure, rice mill wastes, cow dung and pig dung (Ano, *et al*., 2005) has variously been used and in modern Agriculture is regarded as organic farming. However, the use of wastes from animals, humans and vegetable sources for soil amendment and in improving crop production is as old as agriculture. Organic manure on the other hand is known to be effective in maintenance of adequate supply of organic matter in soils with attendant improvement in soil physical and chemical conditions and enhanced crop performance (Ikpe and Powel, 2003). It improves the physical structure of the soil as well as the chemical properties by supplying the nutrient requirements of the crop. Ikpe *et al*. (1999) reported that about75% of farmers in the forest zone of West Africa keep

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livestock predominantly goat and poultry. There is need to make use of this abundant organic manure in soil amendment and enhance crop yield. The objective of this trial was to determine the effect of the organic manure on the yield components and root yield of sweetpotato grown on soil amended with goat (dropping) manure

II. Material and Methods

The experiment was conducted at the National Root Crops Research Institute, Umudike in South eastern Nigeria. Umudike lies between (latitude 05° 29"N; longitude 07 ° 38"E) and located in the humid tropical rainforest zone. There are two main seasons, namely the rainy season and the dry season (NRCRI Meteorology station 2010 and 2011). The rainy season starts in April and lasts till October with a pronounced break around August, while the dry season lasts from December through February. Temperature is constantly high with annual daily maximum and minimum of 32 ° C and 24° C respectively. Land clearing and ridge making were done mechanically. The soil was analyzed. The cultivars of sweetpotato used were TIS87/0087, TIS440293, TIS 8164 and TIS2532. OP.1.13. Four levels of organic manure were also applied. The first level, Lo, was the control i.e. no manure application. The other levels (L_1) were (5t/ha), the second level (L_2) was (10t/ha) and (L_3) was (15t/ha). The experiments were laid out in a factorial randomized complete block design (RCBD) with 4 replications. The proposed levels of organic manure were incorporated into the ridges one week before planting on the appropriate plots. The sweetpotato cuttings 30cm were sown 30cm apart within the row and 1m between ridges. Weeding hoe was used at the early stage to enhance addition of soil to the base of the plants during roots bulking. Hand pulling followed, to ensure minimum disturbance of the vines especially as the nodes became adventitious when they touch the soil. Data on leaf area, vine length, number of branches, number of leaves, vigour, total root yield, were collected and analyzed statistically using analysis of variance (ANOVA) and means were separated using the least significant difference (LSD) at 5% level of probability (Steel and Torrie., 1981). Correlation analysis were used to select plant characters that contributed significantly to root yield under the influence of goat manure.

III. Results and Discussion

The physico-chemical properties of the soil are in table 1. The result of the soil analysis showed that the soil was sandy loam under the soil textural classification (Table 1). The pH was 5.45 and 4.70, which indicated that the soil was slightly acidic. The result showed that the total nitrogen content and Organic carbon content of the soil of the experimental sites were low. This revealed that there is need for application of nutrients to enhance the performance of the soil for crop production.

Table 1 : Soil Physico-Chemical before planting and after planting and Composition of the Goat Manure.

Soil characteristic	before planting	after planting
Sand (%)	52.40	54.41
Slit	22.80	18.67
Texture (%)	**sandy clay loam**	**sandy clay loam**
pH (H_2o)	5.45	4.30
Available P ($mgkg^+$)	20.40	17.16
Total N (%)	0.09	0.15
Organic carbon (%)	0.99	1.76
Organic matter (%)	1.70	3.03
Ca^{2+} (coml. kg^{-1})	3.60	3.55
Mg^{2+} (coml. kg^{-1})	1.60	1.81
K^+ (coml. kg^{-1})	0.14	0.15
Na^+ (coml. kg^{-1})	0.209	0.19
Exchange acidity (Coml. kg^{-1})	3.52	7.86
(%) Base saturation	61.19	72.37

Goat Manure	Chemical Composition
Available P (mg kg^+)	0.34%
Total N (%)	2.24%
Ca^{2+} ($cmolkg^{-1}$)	2.20%
Mg^{2+} (coml. kg^{-1}	0.97%
K^+ (coml. kg^{-1})	0.14%
Na^+ (coml. kg^{-1})	0.67%

The results of the Analysis of variance for the responses of the Plant Characters to different Levels of organic manure are presented in T able 2.

Table 2: Analysis of variance showing the Mean square for the Responses of Metric of Plant Characters to Different Levels of Organic Manure

Sources of Variation	Degree of Freedom	Vines length (cm)	leaf area (cm^2)	Vigor	branch primary	No. of leaf	total fresh Roots wt (kg)	No of marketable Roots yield
Replication	3	644.56ns	9083.0**	0.80ns	3.08**	10.62*	4.74	136.625ns
Variety	3	2443.59ns	1472.18 **	3.30**	0.2ns	51.62**	50.69**	607.375**
O.M	3	41817.79**	3602.11**	8.18**	3.3**	183.55**	71.72 **	1325 **
O M& V	9	1137.82ns	380.15**	1.01ns	0.3ns	19.03*	2.64 ns	397.55**
Error	45	5779.50	77.92	70.66	0.16	3.44	4.78	6.57

The result showed that there was high significant (P<0.01) differences in the responses of the plant characters to the different levels of application of goat manure except for the vine length. There were non-significant differences in the interaction between the organic manure and the sweetpotato varieties except on the leaf area, number of leaves and on total fresh root yield.

IV. Mean Total root weight and Total number of roots

The result of the effect of goat manure application on mean total root weight and total number
of roots obtained during 2010 and 2011 cropping seasons are presented in Table 3

Table 3: Combined mean Total root weight and Total number of roots during 2010 and 2011 cropping season

	Total roots weight (t/ha)					Total number of roots				
OMt/ha	TIS87/0087	TIS440293	8164	TIS2532 op.1.13	Mean	TIS87/0087	TIS440293	8164	TIS2532 op.1.13	mean
0t/ha	2.37	2.57	3.52	0.27	2.18	28.0	17.2	24.2	6.0	18.8
5t/ha	4.90	3.52	7.75	0.59	4.19	44.2	26.0	27.7	8.0	26.4
10t/ha	5.65	4.21	7.67	1.17	4.67	47.7	21.0	32.2	20.2	30.3
15t/ha	6.37	6.85	9.10	6.17	7.24	45.7	28.5	28.5	24.7	31.8
mean	4.94	4.28	7.01	2.05		41.4	23.1	28.1	14.7	

LSD $_{(P<0.05)}$:
Genotype 2.82,**
Goat manure ns
Genotypes x Goat manure ns

LSD $_{(P<0.05)}$
Genotypes 2.86,**
Goat manure 15.87*,
Genotypes x Goat manure

The result showed that mean total root weight of 2.18t/ha was obtained when 0t/ha of goat manure was applied. However, yield increased when application of goat manure increased from 5t/ha, 10t/ha to 15t/ha which gave mean yield increase of 4.19t/ha, 4.67t/ha and 7.24t/ha respectively. This result indicated that as the application of goat manure increased, yield increased.

The variety 8164 responded well to the application of goat manure with mean yield of 7.01t/ha followed by the variety TIS87/0087 with mean yield of 4.94t/ha while 440293 responded low to the application of goat manure with yield of 4.28t/ha when compared to other sweetpotato varieties.

With 0t/ha application of goat manure, the mean number of sweetpotato roots produced was 18.8 sweetpotato root/1000/ha. When the application of goat manure increased from 5t/ha, 10t/ha to 15t/ha, number of sweetpotato roots increased from 26.4, 30.3, to 31.8 per1000/ha respectively of numbers of sweetpotato roots. However, the variety 8164 produced 28.1 numbers of roots /1000/ha when compared with other sweetpotato varieties followed by the variety 440293 with 23.1sweetpotato roots/1000/ha. The variety 2532.OP.1.13 had the least number of sweetpotato root with 14.7 number of roots/1000/ha.

Mean of Leaf area cm^2 and vine length

The result on the effect of goat manure on mean of Leaf area cm^2 and vine length during 2010 and 2011 cropping season is presented in Table 4

Table 4: Effect of goat manure on mean of Leaf area cm^2 and vine length during 2010 and 2011 cropping season

Leaf area **Vines length**

OMt/ha	TIS87/0087	TIS440293	8164	TIS2532 op.1.13	Mean	TIS87/0087	TIS440293	8164	TIS2532 op.1.13	Mean
0t/ha	29.45	41.55	49.73	25.73	36.61b	186.9	85.46	72.5	170.2	128.30b
5t/ha	58.80	63.98	63.38	88.30	68.61a	186.9	110.16	117.60	152.60	141.80a
10t/ha	63.63	63.38	74.23	51.65	63.22a	216.47	84.20	113.10	160.20	143.60a
15t/ha	53.4	80.70	91.65	49.10	68.71a	211.7	98.60	113.70	205.30	158.97a
mean	51.32	62.75	69.756	53.69		200.49	94.61	104.22	172.15	

LSD $_{(P<0.05)}$**:**
Genotypes 54.43**
Goat Manure 21.17**
Genotypes X Goat manure 11.34**

LSD $_{(P<0.05)}$
Genotypes ns
Goat Manure Levels 35.39,**
Genotypes x Goat manure ns

The result in Table 4 showed the effect of goat manure on the leaf area and vine length of the sweetpotato varieties. At the application of 0t/ha of goat manure, the mean leaf area of the sweetpotato varieties was 36.61 cm^2 while at the application of 15t/ha, the leaf area increased to 68.17cm^2 per plant plant. However, the variety 8164 responded strongly to the application of goat manure with leaf area of 69.75cm^2 followed by the variety 440293 with leaf area of 62.45cm^2. The variety TIS87/0087 responded poorly to the application of goat manure with leaf area of 51.32cm^2.

The mean vine length of 128.3cm per plant was obtained from the application of 0t/ha of goat manure whereas with the application of 15t/ha of goat manure, the vine length of the sweetpotato varieties increased from 128.3cm to 158.97cm per plant. The variety 87/0087 responded very well to the application of the goat manure with vine length of 200.49cm per plant. This was followed by the variety TIS2532.OP.1.13 with vine length of 172.15cm while the variety 440293 responded poorly to goat manure application with vine length of 94.61cm. The result indicated that not all the varieties responded well in vine length to the application of goat manure.

Mean number of leaves and vigour The result of the effect of goat manure on combined mean number of leaves and vigor score during 2010 and 2011 cropping seasons are presented in Table 5.

Table 5. Effect of goat manure on combined mean number of leaves and vigor score during 2010 and 2011 cropping seasons

	Number of leaves					Vigour rating				
OMt/ha	TIS 87/0087	440293	8164	TIS2532 .OP.1.13	**Mean**	TIS 87/0087	440293	8164	TIS2532. OP.1.13	**Mean**
0	17.95	13.28	16.58	19.85	**16.91**	3.50	3.40	3.75	3.00	**3.41**
5	25.08	16.03	16.95	21.15	**19.80**	3.50	4.75	3.50	4.25	**4.06**
10	24.25	18.08	21.33	23.00	**21.66**	4.75	4.25	5.00	5.50	**4.88**
15	26.63	16.00	20.45	23.63	**21.68**	5.00	5.00	5.00	4.70	**4.93**
Mean	**23.47**	**15.84**	**18.83**	**21.91**		**4.19**	**4.35**	**4.06**	**4.36**	

LSD $_{(P<0.05)}$
Genotypes ns
Goat Manure rates 8.35**
Genotypes X Goat Manure ns

LSD $_{(P<0.05)}$
Genotypes 0.41**,
Goat Manure 0.17**,
Genotypes x Goat Manure= ns

Note Plant vigour score base on visual rate of ground cover: 3 = low (<50%). 5 = medium (50-74%), 7 = high (75-90%), 9 = total ground cover (90-100%).(IBPGR 1991

At 0t/ha application of goat manure, the mean number of leaves was 16.91, while when the application of goat manure increased from 5 to 15t/ha, the number of leaves increased from 16.91 leaves per plant to 21.68 number of leaves per plant. However, the variety 87/0087 responded well to the application of goat manure with 23.47 numbers of leaves per plant followed by TIS2532.OP.1.13 with 21.91 number of leaves per plant while440293 responded very low with 15.84 number of leaves per plant.

The result of effect of goat manure on the vigor score of the sweetpotato varieties during 2010 and 2011 cropping seasons are presented in Table 5. The vigour score rating showed that at 0t/ha application of goat manure the vigour score rate of the sweetpotato varieties was 3.41 while at 5 to 15t/ha application of goat manure, the sweetpotato vigour rating increased from 4.06 to 4.93 vigour rating. However, 8164, responded well to the application of goat manure than other varieties with the score rate of 4.36 followed closely by TIS87/0087 with score rate of 4.35 while TIS8164 had the lowest vigour rate of 4.06.

Correlation between Pairs of Plant Characters: The correlation analysis between pairs of characters as influenced

by goat manure as soil amendments to enhance yield and yield components traits are presented in Table 6

Table 6: Correlation Analysis between Pairs of Plant Characters

	Leaf area	Stand count at harvest	No. of Branches	Plant vigour	Total Number of Roots	Vine Length	Number of leaf	Total root weight t/ha
Leaf Area	1	.431**	.261*	.450**	.504**	.095	.140	.496**
Stand count at harvest		1	.121	.395**	.0171	.381**	.393**	.467**
Number of Branches			1	.310*	.369**	.012	.105	.346**
Plant vigour				1	.529**	.412**	.375**	.689**
Number of Leaf					1	.837**	.032**	.443**
Total Number of roots						1	.261*	.386**
Vine Length							1.	339**
Total weight t/ha								1

*, ** Significant at 5% and 1% levels of probability respectively.

The result in table 6 is the simple linear correlation between total root weight and other plant characters. Total root weight had positive significantly correlation with stand count at harvest (r = .496**), number of branches (r = .837**), and plant vigour (r = 689**). Also total root weight had high positive significant correlation with total number of roots (.r=837**), vine length (r = .032**) and number of leaves(r = .443**). This result indicated that as the level of goat manure increased, this led to the increased performance of the plant characters resulting in increased vigour. This increased vigour led to increased total root weight and root number which is also a function of yield (Nwankwo et al., 2014).

V. Discussion

The result of the soil analysis showed that the soil was sandy loam under the soil textural classification (Table 1). The pH was 5.45 and 4.7 indicated that the soil was slightly acidic. According to Onunka et al (2012) sweetpotato can perform in acidic soil with appreciable yield. The result showed that the total nitrogen content and Organic carbon content of the soil of the experimental site were low. This showed that there is need for application of nutrients such as goat manure for high vegetative and root yield of the sweetpotato crop.(Table1).

The application of goat manure from 5t/ha increased the average vine length from 141.8cm to 159cm. the average vine length in plot that received no application of goat manure was low (128.3cm).The increased in vine length in response to increased levels of goat manure could be attributed to enhanced availability of nutrients released in the soil by the goat manure. The uptake of the nutrients by sweetpotato crops led to increase in vine length of the sweetpotato vines. This finding collaborated with the work of Najm et al., (2010) who reported high significant vine length of sweetpotato in response to the application of cattle manure. The variety TIS 87/0087 responded well to the levels of application of goat manure with respect to vine length of 200.49cm followed by TIS TIS2353 OP.1.13 which had 172.15 cm while the least was the variety 440293 with vine length of 94.61cm. However, the increase difference from applied plots and non applied plots indicated that goat manure increases vine length.

The analysis of variances showed that the leaf area of the sweetpotato genotypes increased significantly (P<0.01). This indicated the response of the sweetpotato varieties to the levels of application of goat manure (Table 2). As the application of goat manure from 5t/ha to 15t/ha, the leaf area increased significantly and linearly from 68.61cm to 68.71cm. Although it was significant, the significant difference was not much. However, the plots that received no application of goat manure had lower leaf area of 36.61cm (Table 4). As the levels of goat manure increased, this leads to the increased development of the leaf area which may in turn led to higher photosynthetic efficiency and high yield. Goat manure contain Nitrogen, Phosphorous and potassium and other organic Carbon which holds enough water and makes the nutrient available to the crop. This is in line with Olusola (2009) that mineralization is the process involved in the release of elemental nutrients from organic matter for plant use. These had promoted increased leaf area. Of all the sweetpotato varieties, the variety TIS 8164 responded well to the levels of application of goat manure having mean leaf area of 69.75cm^2 followed by 440293 (62.45cm^2) while TIS 87/0087 responded less (51.32cm^2) . Goat manure could be used to improve the leaf area performance of the two varieties.

The result of the means square analysis of variance for the average number of leaves per plant showed high significant (p<0.01) effect of goat manure on the mean number of leaves per sweetpotato plant (Table 2). Like in other parameters, as the levels of goat manure increased from 5t/ha to 15t/ha, the number of leaves of the sweetpotato varieties increased, from mean of 19.80 to 21.68 numbers of leaves. From this result, it could be concluded that as the rate of goat manure increased, number of leaves also increased thereby promoting photosynthetic efficiency which translate to increase roots yield. From the result, TIS 87/0087 responded to the levels of application of goat manure with mean number of 23.47, followed by TIS 8164 with 18.83 leaf number while the least was 15.84 (Table 5). This indicated that goat manure could be used to promote the leaf number of the two sweetpotato varieties (TIS 87/0087and TIS 8164). This confirmed the work of Adami (2012), on sweetpotato and farm yard manure, which as the rate of farm yard manure increased, the development of green top increased at the expense of root yield production.

The means square analysis of variance for the vigour of sweetpotato showed that the rate of goat manure applied was statistically significant (P<0.01) (Table 2). As the application

of goat manure increased from 5t/ha to 15t/ha the vigor increased from 3.41 score rating to 4.93 score rating. The increased in vigour in response to increased levels of goat manure was as a result of available nutrients released in the soil by goat manure and the uptake of the nutrients by the sweetpotato roots. This led to increased vegetative growth. This is in line with the observations of Marschner (1995) and Gupta and Sharma (2000) that nitrogen promotes vegetative growth. The result is also in line with Tesfaye et al., (2008), who reported that application of the maximum farmyard manure help to increase foliage development for better fresh foliage production for livestock feed (Table 5).

The result of the simple linear correlation between total root weight and other plant characters indicated that total root weight had positive significant correlation with other plant characters which showed that as the levels of goat manure increased, this led to the increased performance of the plant characters with increased vigour. This increased vigour led to increased total root weight and root number which is also a function of yield (Nwankwo et al., 2014). Based on this result, goat manure could be utilized for increase sweetpotato production since it contributed significantly in root yield in sweetpotato production through influencing plant character performance.

VI. Conclusion

The information on goat manure on soil fertility level and the response of sweetpotato varieties to goat manure management practices is very important to come up with profitable and sustainable sweepotato production management package using the goat manure that is readily available in most households in South eastern Nigeria. Although not all the sweetpotato varieties responded very well to the application of goat manure, however, research has shown that the application of goat manure not only supplies nutrients but also improves physical and chemical properties of the soil and thereby improving the yield of sweetpotato. In addition, the positive significant correlation between total root yield and other plant characters (total number of roots (r=0.386**), vine length (r = 0.339**), plant vigour (r=0.689**), number of branches(r=0.346**), leaf area (r=0.496**) and number of leaves (r = 0.443**) indicated that goat manure contributed significantly (P<0.01) in the performance of the plant characters which altogether led to root yield. As the levels of application of goat manure increased, the yield and yield component parameters increased linearly indicating that 15t/ha of goat manure is not the optimum for sweetpotato production. There is therefore the need to find the optimum level of goat manure required for sweetpotato production.

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