EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON SWEETPOTATO GENOTYPES FOR YIELD STABILITY

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Abstract

A field experiment was carried out in 2013 and 2014 at the National Root Crops Research Institute, Umudike, in the rainforest zone, to evaluate the effect of organic and inorganic fertilizer on sweetpotato genotypes for yield stability. The experiment was carried out using a split plot in a randomized complete block design replicated three times. The treatments included ten fertilizer levels (NPK 15:15:15 fertilizer (100kg/ha, 200kg/ha, 300kg/ha); poultry manure (10t/ha, 20t/ha, 30t/ha and combination of NPK 15:15:15 and poultry manure: 5t/ha+50kg/ha NPK, 10t/ha+100kg/ha NPK, 15t/ha+150kg/ha NPK and 0t/ha PM/NPK as control); and eight sweetpotato genotypes: Centennial, Ex-Oyunga ,UMUSPO/3 UMUSPO/1, NRPS/05/3D, Ex-Igbariam, TIS/8164, and TIS/87/0087 were involved in the trial. Data on some growth and yield parameters were measured and subjected to Genotypes and Genotype -by- Environment interaction (GGE) biplot and Additive Main effects and Multiplicative interaction (AMMI).The results revealed that UMUSPO/1 (G8), TIS/87/0087 (G6) and TIS 8164 (G5) had significant mean saleable root yield (t/ha) above the grand mean and largest IPCA1 scores respectively, while Centennial (G2) Ex-oyunga (G4) and NRSP/05/3D (G1) had low saleable root mean yield and lowest IPCA1 score. Results also showed that yield increase are not totally due to genetic potential of the cultivars but also due to improved agronomic practices with observed good yields supported by environments such as 10t/ha poultry manure in 2014 (E12), 10t/ha poultry manure + 100kg/ha NPK in 2013 (E9), 5t/ha poultry manure + 50kg/ha NPK in 2013 (E8) and 30t/ha poultry manure (E4) in 2013. From the results, sweetpotato farmers can cultivate any of the genotypes in any of the E4, E8, E9 and E12 environments for high saleable root yield of sweetpotato.

Key words: Organic, inorganic, AMMI, genotype x environment interaction and saleable root yield

Introduction

Sweetpotato is an important source of food for human consumption, feed for animals. It is an important food security crop and has the potential to improve the household income of rural dwellers by commercial production of the fleshed root for local market and export. Sweetpotato is cultivated over a wide range of environments with varying yields across these environments. In Nigeria, large number of farmers often erroneously consider sweetpotato as a crop associated with poor soil because no matter how poor the soil is, fresh roots will still develop. However, this is one of the reasons for poor root yield of 3t/ha to 8t/ha in farmers' fields (Njoku, *et al* 2009, Eke-Okoro, *et al* 2010). Low soil fertility has been recognized as one of the major production constraints affecting agriculture. Soil fertility depletion in small holder farms is the fundamental issue (Sanchez *et al.,* 1996). This depletion is mainly due to intensive and continuous cropping with low application of nutrients. The low and declining productivity of many tropical soils are the major constraints limiting the realization of the improved genetic potential of crop that is now available. As poor soil fertility limits the realization of the genetic potential of the crop, fertilization of the sweetpotato crop becomes inevitable. According to (Nwinyi *et al.,* 1987) the recommended fertilizer rate for sweetpotato is 300-400kg/ha. However, in many rural farming communities, the shortage and high cost of inorganic fertilizers have limited their use for crop production (Tanimu *et al.,* 2007). Poultry manure is essential in crop production as local farmers use it regularly on their farms for improving the fertility of their sweetpotato farms (Ibeawuchi *et al.*, 2006). Maynard (1991) observer that many crops responded well to the application of organic manure, and that organic manure could sustain yield under continuous cropping on most soils unlike equivalent amount of NPK fertilizer. Poultry manure has been adjudged to be most valuable of all manures produced by livestock. Moreover, the nutrient content of poultry manure ranks among the highest of all animal manures, and the use of poultry manure as soil amendment for agricultural crops will provide appreciable quantities of all the major plant nutrients. Both organic and inorganic fertilizers supply plant nutrients to crops at different rates and over different period of time. The need to study the stability of saleable root yield, the most important yield component, across the various levels of organic and inorganic fertilizers and their combinations justify this work.

Materials and Method

Experimental site description: The experiments were conducted at the National Root Crops Research Institute Umudike. Umudike in rainforest zone is located on Latitude 5^{o} 20" N and Longitude 07^{o} 32"E; Altitude 122m. Umudike is in the humid tropics and with a total rainfall of about 2177 mm per annum, annual average temperature of about 26^{0}C. The predominant vegetative type is rain forest (NEST, 1991) while the soil has been classified as sandy loam ultisol (Agboola, 1979). Relative humidity varies from 51% to 87% and the sunshine hour varies from 2.69 to 7.86 hours per day. Umudike has two rainy seasons and the dry season. The rainy season usually commences from March to late October is bi-model in pattern and comprise early rain (March-July) and late rain (August-October) with a dry spell in August and dry season that lasts from December through February.

Experimental treatments: There were 10 fertilizer levels and eight genotypes involved in the trial. The fertilizer treatments comprised of: **t**hree rates of inorganic fertilizer NPK 15:15:15 (100, 200 and 300kg/ha); three rates of poultry manure (10, 20 and 30t/ha), three combinations of organic and inorganic fertilizers: (5t/ha PM +50kg NPK, 10t/haPM+100kg/ha NPK and 15t/ha PM +150kg/ha NPK); and the control which was 0kg NPK and 0kg poultry manure). Of the eight (8) genotypes of sweetpotato that were involved, four were orange-fleshed, namely: Ex-Oyunga, Centennial, UMUSPO/3 and UMUSPO/1; and four were white-fleshed: NRSP/05/3D, TIS87/0087, TIS/8164 and Ex-Igbariam.

Experimental design: The experiment was laid out as a split-plot design in randomized complete block design (RCBD) with three (3) replicates each year. Fertilizer was the main plot and sweetpotato genotypes as the subplot treatments. The subplots measured 2 m by 3 m^{2}, and the sweetpotato vines were planted with inter- and intra- row spacing of 100 cm x 30 cm, giving plant density of 20 stands per plot and 33,333 plants/ha. Four node vines cuttings were used for the planting. The vine cuttings were planted at the crest of the ridge at an angle of 45^{0} with two nodes buried. Planting was done in Year 1 on 24th June, 2013, and in Year 2 on 25th June, 2014. The inorganic fertilizer treatments were applied at four weeks after planting (WAP) while poultry manure at different rates was applied at four WAP. Weeding was done manually at 4 weeks after planting before treatment application, while subsequent weeds found were rogued. In each year of the experiment, harvesting was done in October. During harvesting, fresh roots weighing >100 g were selected as saleable roots, and those $\leq$ 100 g were considered as unsaleable roots. Yield stability analysis was carried out on saleable root yield (t/ha). Stability analysis was performed using Genotype and Genotype -by- Environment Interaction (GGE) biplot and the Additive Main effects and Multiplicative Interaction (AMMI) models according to Gauch (1992) and Gauch *et al.* (1989). The results of the two models are further presented in form of biplots.

Results and Discussion

Table 1 revealed the results of the Additive Main effect and Multiplicative Interaction (AMMI) analysis for saleable root yield (t/ha) of the eight sweetpotato genotypes across the 20 micro environments with their IPCA1**.** The results showed that the means of the genotypes ranged from 0.82t/ha for Ex-Oyunga to 14.97t/ha for UMUSPO/1. Three genotypes (UMUSPO/1, TIS/ 87/0087 and TIS 8164) out of the eight genotypes had above average saleable root yields of 14.97, 11.37 and 10.20 t/ha respectively, and were also consistent in almost all the environments. The remaining genotypes had consistently below average saleable root yield in all the environments. UMUSPO/1 also had the highest positive IPCA1 score of 3.66 and TIS/ 87/0087 recorded the highest negative IPCA1 value of -2.36. The lowest IPCA1 score was observed in Centennial (0.13). Large positive and negative IPCA1 scores imply high interaction and thus low stability and inconsistence of genotypes across environments while small IPCA score implies low interaction and high genotype stability across environments (Thiyagu *et al*. 2013). Thus, genotypes UMUSPO/1 (G8), TIS/87/0087 (G6) and TIS 8164(5) which had the highest mean saleable root yield will be good genotypes for farmers to cultivate for higher productivity in any of the environments, but with unpredictable stability. The remaining genotypes are more stable in their low saleable root yield production. This result is in line with the assertion by Kamadi (2001) that high yielding genotypes are often unstable.

Although the environments did not differ significantly in their mean performance, the highest mean saleable root yield was recorded in 30t/ha poultry manure in 2014 (E14) which had a mean saleable yield of 8.01t/ha followed by combination of 10t/ha poultry manure + 100kg/ha NPK saleable root yield of (7.94t/ha) in 2014 (E19) and combination of 15t/haPM+150kg/ha NPK 15:15:15 had mean saleable root yield of (7.73t/ha) in 2013 (E10). The environments with the lowest mean saleable root yield were 100kg/ha NPK in 2013 (E5) and on zero application of fertilizer in 2014 (E1) with mean saleable root yields of 5.21t/ha and 5.32t/ha respectively.

Table 1: AMMI Analysis showing the saleable root yield (t/ha) of eight sweetpotato genotypes across 20 environments with their IPCA1scores

Environments	NRPS/05/3D	Centennial	Ex-Igbariam	Ex-Oyunga	TIS/8164	TIS/87/0087	UMUSPO/3	UMUSPO/1	Mean	IPCAe1
E1	3.29	2.21	5.12	0.10	10.2	15.95	1.16	4.51	5.32	-2.43
E2	5.69	4.90	7.20	2.35	13.1	16.23	1.60	7.90	7.36	-2.04
E3	5.30	5.04	6.61	1.99	13.3	13.74	1.95	9.13	7.13	-1.55
E4	4.16	4.99	5.15	1.02	11.6	10.21	3.96	14.25	6.92	-0.10
E5	2.69	2.75	4.11	0.39	9.52	12.10	1.12	9.76	5.21	-0.99
E6	3.10	3.25	4.71	0.29	8.40	14.74	3.03	12.72	6.29	-0.67
E7	3.61	3.52	5.03	0.47	10.70	13.05	1.43	9.52	5.92	-1.22
E8	3.79	4.57	4.83	0.68	11.10	10.24	3.59	13.82	6.58	-0.14
E9	2.73	3.43	4.43	0.18	6.77	14.79	5.07	16.85	6.78	0.19
E10	5.00	6.42	5.56	1.73	13.5	7.58	5.40	16.65	7.73	0.51
E11	2.39	3.83	3.22	0.63	9.48	7.21	4.00	16.05	5.85	0.72
E12	3.76	4.72	5.03	0.93	9.55	12.18	5.28	16.79	7.28	0.28
E13	3.22	4.77	4.24	0.42	9.06	9.74	6.16	19.18	7.10	1.03
E14	4.17	5.41	5.39	1.42	9.62	12.30	6.67	19.09	8.01	0.69
E15	3.08	4.41	4.03	0.17	9.46	9.37	5.03	17.20	6.60	0.68
E16	3.32	4.80	4.28	0.44	9.59	9.35	5.73	18.33	6.98	0.88
E17	3.52	5.02	4.61	0.76	9.11	10.62	6.54	19.55	7.47	0.99
E18	2.99	4.67	3.91	0.16	9.06	8.75	6.06	19.29	6.86	1.16
E19	4.33	6.27	4.94	1.33	11.4	7.56	7.15	20.47	7.94	1.35
E20	3.70	4.91	4.90	0.92	9.29	11.67	6.01	18.27	7.46	0.63
Mean	3.69	4.50	4.87	0.82	10.20	11.37	4.35	14.97	6.85	
IPCAg1	-0.63	0.13	-0.86	-0.51	-0.96	-2.36	1.52	3.66		

Footnote: 0t/ha poultry manure/NPK (E1), 10t/ha poultry manure (E2), 20t/ha poultry manure (E3), 30t/ha poultry manure (E4), 100kg/ha NPK (E5), 200kg/ha NPK (E6), 300kg/ha NPK (E7), 5t/ha poultry +50kg/ha NPK (E8), 10t/ha poultry +100kg/ha NPK (E9), 15t/ha poultry +150kg/ha NPK(E10), 0t/ha poultry manure/NPK (E11), 10t/ha poultry manure (E12), 20t/ha poultry manure (E13), 30t/ha poultry manure (E14), 100kg/ha NPK (E15), 200kg/ha NPKE (16), 300kg/ha NPK (E17), 5t/ha poultry +50kg/ha NPK (E18), 10t/ha poultry +100kg/ha NPK (E19), 5t/ha poultry +50kg/ha NPK(E20); and NRSP/05/3D (G1), Centennial (G2), Ex-Igbariam (G3), Ex-Oyunga(G4), TIS8164 (G5), TIS87.0087 (G6). UMUSPO/3 (G7) UMUSPO/1(G8).

Biplot for saleable root mean performance and ideal genotype

Additive Main effect and Multiplicative Interaction biplots of mean performance of eight sweetpotato genotypes across two years of assessment are presented in (Figure 1). The biplot explained that more than 65.5% of the total variation occurs in individual genotype. The highest mean saleable root yields were found on UMUSPO/1(G8), TIS87/0087 (G6) and TIS8164 (G5) genotypes with difference in their stability. Among the high yielding genotypes, TIS 8164 was the most stable in saleable root yield under a given set of environments. The same Figure 1 showed that Centennial (G2) and UMUSPO/3 (G7) genotypes produced the lowest mean saleable root yield with high stability performance. UMUSPO/1 and TIS 87/0087 showed high interaction of IPCA score. This implied that the inconsistency in their saleable roots yield was caused by wide difference in expression of the trait by each genotype. Also, NRSP/05/3D (G1), Centennial (G2) and Ex-Oyunga (G4), genotypes, had low interaction IPCA score indicating poor expression of their trait but high stability performance. This implies that NRSP/05/3D (G1), Centennial (G2) and Ex-Oyunga (G4) genotypes had specific gene for stability and can be use for further breeding work for stability variety. The finding of Thiyagu *et al*., (2013) agreed with the present result that large IPCA score either (negative or positive) implies high interaction and thus low stability while small IPCA score implies low interaction and thus high stability.

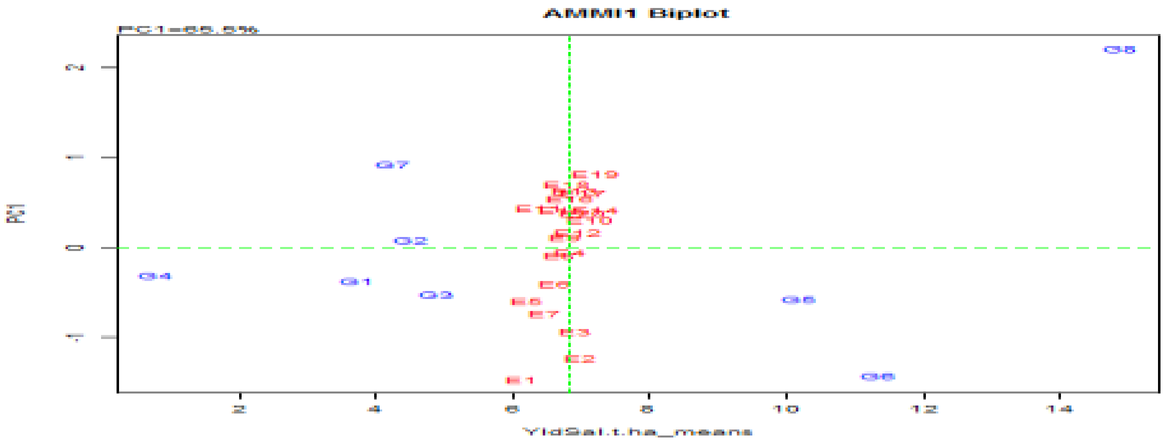

Figure 1: AMMI analysis of saleable root yield of eight sweetpotato genotypes

Footnote: 0t/ha poultry manure/NPK (E1), 10t/ha poultry manure (E2), 20t/ha poultry manure (E3), 30t/ha poultry manure (E4), 100kg/ha NPK (E5), 200kg/ha NPK (E6), 300kg/ha NPK (E7), 5t/ha poultry +50kg/ha NPK (E8), 10t/ha poultry +100kg/ha NPK (E9), 15t/ha poultry +150kg/ha NPK(E10), 0t/ha poultry manure/NPK (E11), 10t/ha poultry manure (E12), 20t/ha poultry manure (E13), 30t/ha poultry manure (E14), 100kg/ha NPK (E15), 200kg/ha NPKE (16), 300kg/ha NPK (E17), 5t/ha poultry +50kg/ha NPK (E18), 10t/ha poultry +100kg/ha NPK (E19), 5t/ha poultry +50kg/ha NPK(E20); and NRSP/05/3D (G1), Centennial (G2), Ex-Igbariam (G3), Ex-Oyunga(G4), TIS8164 (G5), TIS87.0087 (G6). UMUSPO/3 (G7) UMUSPO/1(G8).

Figure 2; shows the GGE biplot environment ranking view for saleable root yield (t/ha).The biplot indicated that the environments did not differ much in their performances since they fall almost on the same point along the performance line. An “ideal” environment was indicated as the most representative as they have the smallest acute angles with the abscissa of the average environment axis. However, in the GGE biplot ranking view, environments such as 10t/ha poultry manure in 2014 (E12), 10t/ha poultry manure + 100kg/ha NPK in 2013 (E9), 5t/ha poultry manure + 50kg/ha NPK in 2013 (E8) and 30t/ha poultry manure in 2013 (E4) were ranked closest to the ‘ideal environment’ and with large PC1 scores and low interactions. The result showed that the performance of saleable root yield of the sweetpotato genotypes was not totally due to genetic potential of the genotypes but also due to improved agronomic practices as a result of the environments. This implies that ideal environments selected have more power to discriminate genotypes in term of genotypic main effect. This present result is in line with the findings of Yan et al., (2000) and Yan and Rajcan, (2002) who reported that the ideal test environment should have large PC1 scores (more power to discriminate genotypes in terms of the genotypic main effect) and small (absolute) PC2 scores (more representative of the overall environments).

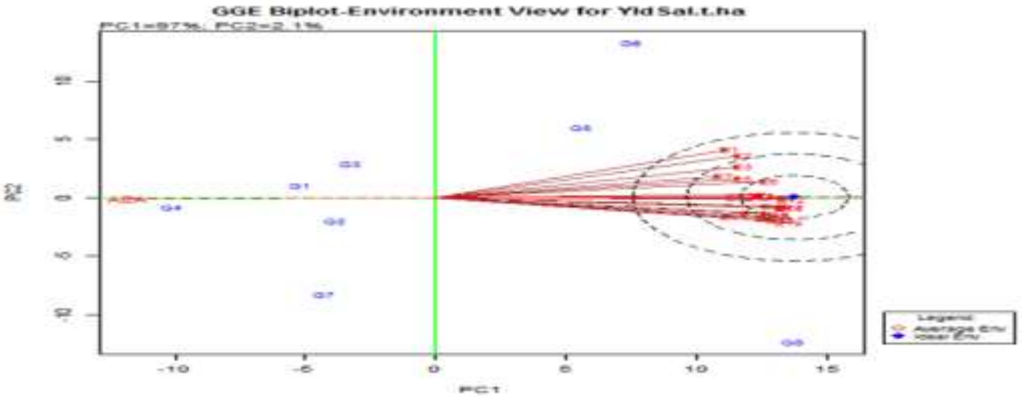

Figure 2: GGE biplot showing environment ranking view for yield saleable (t/ha)
0t/ha poultry manure/NPK (E)1, 10t/ha poultry manure (E2), 20t/ha poultry manure (E)3, 30t/ha poultry manure (E4), 100kg/ha NPK E5, 200kg/ha NPK (E6), 300kg/ha NPK (E)7, 5t/ha poultry +50kg/ha NPK(E8), 10t/ha poultry +100kg/ha NPK (E9), 15t/ha poultry +150kg/ha NPK (E10), 0t/ha poultry manure/NPK (E11), 10t/ha poultry manureE12, 20t/ha poultry manure (E13), 30t/ha poultry manure (E14), 100kg/ha NPK (E1)5, 200kg/ha NPK (E16), 300kg/ha NP (E17), 5t/ha poultry +50kg/ha NPK (E18), 10t/ha poultry +100kg/ha NPK (E19), 5t/ha poultry +50kg/ha NPKE20 and NRSP/05/3D (G1), Centennial(G2), Ex-Igbariam (G3), Ex-Oyunga (G4), TIS8164(G5), TIS87.0087 (G6). UMUSPO/3 (G7) UMUSPO/1(G8)

The result in Figure3 shows that the entire vectors drawn from biplot origin were acute (less than 90^{o}C angle). Even the cosine angle between any two vectors showed acute of less than 90^{o}C. The Figure also showed that some of the environments were high yielding and falls on the right side of the biplot but most of the environments were unstable and fall away from the zero line of the IPCA score. It means that the length of the vectors showed variation among the environments and describes its suitability for genotype discrimination. Also, positive correlation coefficient was observed among the environments. The result implies that selection of any of the environments would improved the yield of any of these target genotypes TIS8164 (G5), TIS/870087 (G6) and UMUSPO1 (G8) since they fall at the high yielding side of the environments. The result showed that the same trend observed among the genotypes for saleable root yield of sweetpotato in one environment will be observed across other environments. This is in agreement with Jandong *et al*., (2011), that genotypes adaptable or higher yielding in one environment may also show similar responses to the other as well.

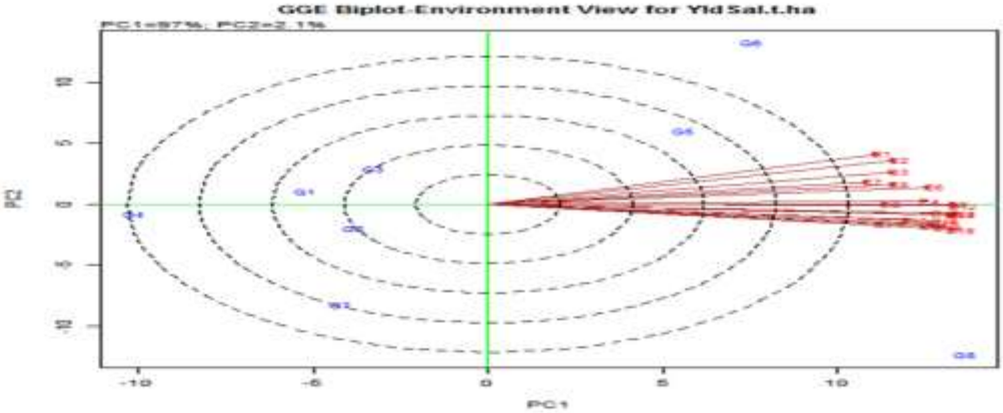

Figure 3: Genotype and Genotype by Environment (GGE) GGE biplot showing relationship among the environments
0/ha poultry manure/NPK (E)1, 10t/ha poultry manure (E2), 20t/ha poultry manure (E)3, 30t/ha poultry manure (E4), 100kg/ha NPK E5, 200kg/ha NPK (E6), 300kg/ha NPK (E)7, 5t/ha poultry +50kg/ha NPK(E8), 10t/ha poultry +100kg/ha NPK (E9), 15t/ha poultry +150kg/ha NPK (E10), 0t/ha poultry manure/NPK (E11), 10t/ha poultry manureE12, 20t/ha poultry manure (E13), 30t/ha poultry manure (E14), 100kg/ha NPK (E1)5, 200kg/ha NPK (E16), 300kg/ha NP (E17), 5t/ha poultry +50kg/ha NPK (E18), 10t/ha poultry +100kg/ha NPK (E19), 5t/ha poultry +50kg/ha NPKE20 and NRSP/05/3D (G1), Centennial(G2), Ex-Igbariam (G3), Ex-Oyunga (G4), TIS8164(G5), TIS87.0087 (G6). UMUSPO/3 (G7) UMUSPO/1(G8)

Conclusion

The yield increase is not totally due to genetic potential of the cultivars but also due to improved agronomic practices which was observed on ideal environments. High saleable roots yields of sweetpotato genotypes can be got across any of the ideal environments such as 10t/ha poultry manure in 2014 (E12), 10t/ha poultry manure + 100kg/ha NPK in 2013 (E9), 5t/ha poultry manure + 50kg/ha NPK in 2013 (E8) and 30t/ha poultry manure in 2013 (E4).

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