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INTEGRATED NUTRIENT APPLICATION EFFECT ON NPK ABSORPTION AND ROOT YIELD OF SWEET POTATO (*Ipomoea batatas* (L) LAM) IN A TROPICAL ULTISOL

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ABSTRACT

A field trial was conducted at National Root Crops Research Institute, Umudike, Abia State Nigeria, in 2004/2005 cropping seasons. The aim was to determine the effect of integration and time of application of two nutrient sources (poultry manure and inorganic fertilizer) on NPK absorption and root yield of sweet potato in an ultisol. Different rates of the two nutrient sources including a control were applied over four time intervals (0, 2, 4, 6, WAP). Results showed that time of application had no significant effect on NPK absorption rate of the crop. Application of equal mixture of the two nutrient sources (50 %) produced the highest root yield and is therefore recommended for optimum NPK absorption and root production.

INTRODUCTION

In recent times, scientists advocate the use of combined organic and inorganic manures for improved crop production. In Mexico, manures are mixed with mineral fertilizers in order to enrich them with nutrients and increase yield. According to Brady and Weil (2002), the timing of nutrient application in the field is governed by several basic considerations. These include making the nutrient available when plants need it, avoiding excess availability especially nitrogen before and after the period of plant uptake and making nutrients available when they will strengthen and not weaken perennial plants.

Application of N from organic and inorganic sources is essential to sustain and improve crop yield in continuous cultivation system. There is a fair body of information on the use of organic fertilizers for sweet potato production but the information is limited compared to other crops.

Potassium is the third major element required for plant growth and is absorbed as potassium ion (K^+) and found in soil in various amounts. All crops including roots and tubers take up potassium at considerable rates and therefore, respond well to potassium fertilization. Potassium is an all important nutrient well known for its effect on tuber storability and quality of potato tubers, promotes repetitive growth, tuber yield and keeping quality during storage Potassium deficiency is normally expected in sandy soils. Sweet potato (*Ipomoea batatas* (L) is one of the most widely grown and valuable crops. It is a short duration crop and a source of various food forms. Woolfe (1992), emphasized that sweet potato (roots and green) can support more people per unit hectare than any other food and that there is need to support the carotene rich cultivars for children in many developing countries. In annual production, sweet potato ranks as the fifth most important food crop in fresh weight basis in developing countries after rice, wheat, maize and cassava. It is cultivated in 114 countries including Nigeria and ranks among the five most important food crops in over 50 countries Srinnivas (2009).

Appropriate integration rate and time of application of organic and inorganic manures to enhance the absorption of the major elements and their corresponding effect on root yield of sweet potato has not been investigated and determined. The objective of this work therefore, is to determine the optimum rate and time of application of the two nutrient sources, their effect on the NPK absorption and root yield of sweet potato in a tropical ultisol of South eastern state of Nigeria.

MATERIALS AND METHODS

This trial was carried out during 2007 and 2005 cropping season at National Root Crops Research Institute Umudike. It is located within latitude 4^0 15 and 7^0 N and longitude 5^0 29^1 and 33^1 East of the equator with an elevation of 122m above sea level. The area was cleared, ploughed, harrowed and ridged mechanically. The cleared area was demarcated into plots of 30 m^2. After land preparation, soil samples were collected with soil auger prior to planting at a depth of 0-15cm. The soil samples were thoroughly mixed and a composite sample was obtained and analysed for some physico-chemical properties shown in table 1. Total nitrogen was determined by Micro Kjedahl method of Bremner (1965). Available phosphorus was extracted by the Bray II method (Bray and Kurtz 1945) while P on the extract was determined by the Murphy and Riley method (1964)

Exchangeable cations were determined by extracting the samples with neutral ammonium acetate. Exchangeable calcium and magnesium were determined by the EDTA titration method of Juo (1979), while potassium and sodium leachate were read using EEL flame photometer. The exchange acidity was determined by extracting 5 g of the soil with 1N KCL and titrating with 0.5N NaOH using phenolphthalein indicator. Effective cation exchange capacity (ECEC) was calculated

Particle size distribution was determined by hydrometer method of Juo (1979). The soil pH was determined on 2:1 Soil suspension using EEL glass electrode meter (Mcleans, 1965). Poultry manure was obtained from Michael Okpara University of Agriculture, Umudike poultry farm.

NRCRI elite sweet potato variety Tis 87/0087 was used for this experiment. Four node vine cuttings were planted at the crest of the ridge of 1m apart at 30cm between stands giving a population of 33,333 plants ha^{-1}, six combination of inorganic fertilizer and poultry manure were evaluated over four applications times 0, 2, 4 & 6 Weeks After Planting (WAP). From the analysis of the poultry manure, 3.2 tons ha^{-1} of it was calculated to contain on equivalent of NPK recommended for the crop, a factorial experiment in Randomized Complete Block Design (RCBD). The mixture of inorganic fertilizer and poultry manure was applied by broadcasting. The Sweet potato enlarged underground roots were harvested after five months each cropping season using digging fork. The corresponding yields in tons ha^{-1} were determined and analysed with mixed model of edition.

RESULTS AND DISCUSSION

The physical and chemical properties of the soil in the experimental area in 2004 and 2005 are shown in Table 1. The percent nitrogen content of the soil in both years were relatively the same. The percentage nitrogen during 2005 was a bit higher, which could be due to previous crop use. The case of nitrogen, factors such as leaching and nitrification could be responsible. The level of phosphorus was lower in 2004 than 2005 cropping season. The previously applied soil amendment may not have been fully exhausted by the crops. Generally, the values of the chemical properties of the experimental area were less in 2004 than 2005 except percentage base saturation and pH. This could be attributed to crop removal as yields were higher in 2004 than 2005 cropping season. According to Laura (1988), it could be due to the nature of the crops and previous treatment applied to these two areas in the previous years. The effective cation exchange capacity in the soil were generally lower than 10.00 cmol kg^{-1} a characteristic of low activity clay soil of South Eastern Nigeria Agbede (1996).

Nitrogen Absorption

The effect of integrated application of poultry manure and inorganic fertilizer on nitrogen absorption of sweet potato during 2004/2005 cropping is shown in Table 2. The highest percentage of nitrogen was absorbed when a combination of 75% inorganic fertilizer and 25% poultry manure was applied. This was closely followed by the application of 100 % inorganic fertilizer and the difference was not significant. There was no significant difference in the absorption rate between the application of 50 % each of the inorganic fertilizer and poultry manure and the absorption rate at the application of a combination of 75% F + 25% PM. The rate of absorption was in the order of 75% F + 25% PM > 100% F > 50% F + 50% PM > 25%F + 75%PM > control.

The nitrogen made available from the 75% F applied increased the availability of nitrogen for absorption at 0 to 2 WAP. This is because inorganic fertilizer is known for immediate release of available nutrient than organic fertilizer. The gradual increase in absorption from 2 WAP to 6 WAP may be due to release of the available nitrogen from the poultry manure complimenting that of inorganic fertilizer. The control had the least nitrogen absorption. Nitrogen absorption at the application of 75% F and 25% PM was not significantly different from the application of 50% each of the amendment materials. The result in 2005 cropping season also showed that the highest percentage of nitrogen was absorbed at application of 75% inorganic fertilizer and 25% PM similar to 2004. Equal percentage of nitrogen was absorbed when 100% F and 50% each of inorganic fertilizer and poultry manure were applied respectively. This was statistically different from the percentage absorbed when 100% F alone and 50% each of both were applied respectively. The least was absorbed at the control. The highest was absorbed at 6 WAP, this was followed by application at 4 WAP. The least was application at planting. The interaction between time of application and mixture was highly significant $p<0.05$. The difference in the percentage absorption of nitrogen between 4 WAP and 6 WAP was significantly different from each other. This implies that 6 WAP is the optimum time for optimum absorption of nitrogen. At 6 WAP probably more nitrogen was made available at the phenological stage of the crop. Poultry manure improves the organic matter in the soil which in turn positively affects the soil structure and aids mineral absorption. This is probably why more nitrogen was absorbed at the application of 25% PM.

Phosphorus absorption

The effect of integrated application of inorganic fertilizer and poultry manure on the phosphorus absorption of sweet potato in 2004 and 2005 is shown in Table 3. The level of phosphorus content at the various mixtures were relatively the same except in the control in 2004. They were in the range of 75%F +25%PM > 100% PM > 50%F >25% F +75% PM > control. There were no significant differences among the treatments except the control. Application of 100% PM, 75%F + 25%PM and 50% each of the amendment materials had similar absorption trend though absorption at the application of 100% PM was lowest at 4 WAP. Absorption of phosphorus at the application of 100% F followed a different trend as it kept rising and falling within the times of application. Phosphorus absorption at the application of 25% inorganic fertilizer and 75% PM was highest at 0 WAP but sharply dropped at 2 WAP. The reduction in the absorption was more gradual from 4 WAP followed by a gradual rise up to 6 WAP.

Time of application was not significant as well, application at 2 WAP recorded the highest absorption of phosphorus. There was no significant interaction between the time of application and mixture ($p<0.005$). In 2005 also, the result of the effect of mixture of poultry manure and inorganic fertilizer on phosphorus absorption of sweet potato showed that the highest quantity of phosphorus was absorbed at the application of 100% PM. The next was application of 75%F + 25%PM.The control gave the least, time of application of 6 WAP gave the highest quantity of phosphorus absorbed. This was followed by application at 2 WAP. The trend of absorption in both time of application and mixture was the same as in previous year.

Potassium absorption:

The effect of integration of inorganic fertilizer and poultry manure on potassium absorption in 2004 and 2005 cropping seasons is shown in table 4. The application at 0 WAP resulted in higher quantity of the element being absorbed when 100% PM, 75% F + 25% PM, were applied while the application of 25% F + 75% PM at 2 WAP resulted in a decrease in the quantity of K absorbed. From 2 WAP application 25% F + 75% PM. 100% F and 75% F + 25% PM resulted in increase in. K absorption up to 4 WAP. The gradual rise and fall observed here could be attributed to the influence of soil amendment materials and the different rates. However, potassium absorption was higher at the application of 75% F and 25% PM. This was followed by the application of 100% PM. There was no significant difference between them. But application at 4 WAP was the highest though not significantly different from the application from the other times. The interaction between the mixture and the time of application was significant ($p<0.05$) The highest quantity of potassium absorbed at the application of 75%F + 25%PM could be attributed to the presence of the poultry manure in the mixture Smith and Adeyinka (2001) and Olayinka (1990), reported that poultry manure increase soil N, P, K, Ca and Mg absorption by maize plant.

In 2005, the result also showed that highest quantity of potassium was absorbed at the application of 50%F + 25%PM each of the two nutrient sources.

This quantity was significantly different from the others while the least was absorbed at the control. The optimum time of absorption recorded here was 4 WAP closely followed by the application at 2 WAP. The interaction between time of application and the mixtures was very highly significant $p<0.005$. More of the element was absorbed at 0 WAP when 50% each of the two nutrient sources were applied but at 2WAP virtually equal quantity of potassium was absorbed from all the rates applied. From 2 WAP, there was increase in the quantity of the element absorbed, more being absorbed from 50% each of the soil amendment materials up to 4 WAP. Between 4 and 6 WAP absorption of potassium declined in all the rates of the mixture. Probably the available potassium in the soil environment had been totally reduced. Root crops remove large amount of nitrogen and potassium from the soil but an adequate quantity of nitrogen and phosphorus seems to be more important in producing good tuber yield especially in cassava.

Root Yield

The effect of integration of inorganic and organic fertilizer and time of application on root yield of sweet potato was not significant in 2004 (Table 5).

However, the result showed that application of 100% inorganic fertilizer gave the highest mean root yield of 21.2 tons/ha, this was closely followed by the application of 50% each of both materials. The yield obtained at the application of 100 % inorganic fertilizer is at variance with the works of D" Souza and Bourke (1986), Floyd *et al*. 1988 and Piston (1990), who observed higher sweet potato yield on interaction at Papua New Guinea. In terms of time of application, 6 WAP gave the highest mean root yield which was not significantly different from the yield obtained at 2 WAP.

In 2005, the highest mean root yield was recorded at the application of 25% inorganic fertilizer and 75% poultry manure Table 5, this was closely followed by 50 % of inorganic fertilizer and poultry manure. This result is in agreement with the above authors. They credited their result to the various factors involved such as the addition of beneficial nutrients in organic matter that are not found in inorganic fertilizer resulting in the improvement of the physical and biological properties of the soil. Time of application of 2 WAP gave the highest yield followed by 6 and 4 WAP respectively. The least was recorded when inorganic was applied. The effect of the mixture was very highly significant ($P<0.001$) while time and interaction were not. This implies that the synergic effect of the two materials gave the best result, while inorganic fertilizer easily releases the nutrients, the poultry manure slowly releases nutrient to sustain the growth and performance of the crops throughout the growing season. This agrees with the result of Onunka and Nwokocha (2003). The near uniform range of root yield recorded by the time of application at 2 WAP in the two year cropping season indicates that 2 WAP is optimal.

CONCLUSION

The result of this work has shown that application of only inorganic fertilizer enhances N P and K absorption. Time of application has no effect on N P and K absorption of the crop. The 50 % each applied as a mixture from 2 WAP produced the highest average root yield and is therefore recommended.

Table 1: Physical and chemical properties of soils of the experimental area in 2004 and 2005 cropping seasons.

Soil parameter	2004	2005
P($H_2$0)	5.4	4.7
		42.32
P mg kg^{-1}	31.2	0.08
N (%)	0.08	0.79
OC (%)	0.71	1.36
OM (%)	1.22	1.36
Ca (mol kg^{-1})	1.6	1.93
Mgz (mol kg^{-1})	1.2	0.93
K (mol kg^{-1})	0.08	0.9
Na (mol kg^{-1})	0.11	0.15
EA (mol kg^{-1})	0.96	0.96
ECEC (mol kg^{-1})	3.96	4.08
BS (%)	72.5	75.75
Sand (%)	74	72
Silt (%)	10	11
Clay (%)	16	17
Texture	Sandy clay loam	Sandy clay loam

Table 2: Effect of time of Poultry manure and inorganic fertilizer application on Nitrogen absorption of sweet potato vines in 2004 and 2005 cropping seasons (%)

	Weeks After Planting (WAP)									
			2004					2005		
Treatment	0	2	4	6	Mean	0	2	4	6	mean
100% Fertilizer	1.65	1.59	1.59	2.12	1.74	1.60	1.58	1.57	2.13	1.72
100% Poulty Manure	1.30	1.65	1.81	1.57	1.58	1.40	1.67	1.83	1.73	1.66
75% Fertilizer + 25% Poultry Manure	2.10	1.36	1.56	2.10	1.78	2.2	1.40	1.6	2.3	1.88
50% Fertilizer + 50% Poultry Manure	1.90	1.48	1.64	1.85	1.72	2.0	1.5	1.52	1.83	1.72
25% Fertilizer +75% Poultry Manure	1.34	1.24	1.62	1.87	1.51	1.40	1.32	1.63	1.84	1.55
Control	1.02	1.29	1.68	1.72	1.42	1.01	1.22	1.61	1.53	1.34
Means	1.55	1.43	1.65	1.87	1.60	1.60	1.45	1.63	1.9	
SED M 0.11									0.10	
SED T 0.07									0.06	
SED MxT 0.018									0.017	

Table 3: **Effect of time of Poultry manure and inorganic fertilizer application on Phosphorus absorption of Sweet potato vines in 2004 and 2005 cropping seasons (%)**

	Weeks After Planting (WAP)									
			2004					2005		
Treatment	0	2	4	6	Mean	0	2	4	6	mean
100% Fertilizer	3.46	1.83	4.80	2.55	3.16	3.47	1.79	4.85	2.54	3.16
100%Poulty Manure	2.82	5.13	2.07	3.84	3.46	2.86	5.12	2.05	3.87	3.48
75% Fertilizer + 25% Poultry Manure	2.39	4.84	3.72	4.89	3.96	2.39	4.86	3.70	4.90	3.96
50% fertilizer + 50% Poultry Manure	3.35	3.37	2.73	3.60	3.26	3.37	3.32	2.71	3.65	3.26
25% Fertilizer +75% Poultry Manure	4.64	1.98	1.57	3.62	2.95	4.61	2.00	1.57	3.60	2.95
Control	1.77	2.28	1.90	1.97	1.98	1.72	2.26	1.71	1.98	1.92
Means	3.07	3.24	2.80	3.41		3.07	3.23	2.77	3.42	
SED M 0.47									0.25	
SED T 0.39									0.61	
SED MxT 0.92									0.33	

Table 4: Effect of time of Poultry manure and inorganic fertilizer application on Potassium absorption of Sweet potato vines in 2004 and 2005 cropping seasons (%)

	Weeks After Planting (WAP)									
			2004					2005		
Treatment	0	2	4	6	Mean	0	2	4	6	mean
100% Fertilizer	0.56	0.86	1.46	0.84	0.93	0.58	0.84	1.48	0.82	0.93
100%Poulty Manure	1.08	1.48	1.33	0.95	1.21	1.10	1.50	1.30	0.94	1.21
75% Fertilizer + 25% Poultry Manure	1.25	1.41	15.3	0.98	1.29	1.27	1.40	1.55	1.00	1.31
50% Fertilizer + 25% Poultry Manure	1.42	1.32	0..52	0.92	0.93	1.43	1.31	1.92	0.90	1.39
25% Fertilizer +75% Poultry Manure	0.99	0.93	1.91	1.08	1.06	0.97	0.99	0.01	0.61	0.90
Control	0.68	1.12	0.95	0.59	0.83	0.68	1.13	0.95	0.58	0.84
Means	1.00	1.18	1.28	0.09		0.01	1.20	1.37	0.81	
SED M 0.17									0.53	
SED T 0.15									0.54	
SED MxT 0.29									0.28	

Table 5: Effect of time of Poultry manure and inorganic fertilizer application on root yield of sweet potato vines in 2004 and 2005 cropping seasons (%)

	Weeks After Planting (WAP)									
			2004					2005		
Treatment	**0**	**2**	**4**	**6**	**Mean**	**0**	**2**	**4**	**6**	**mean**
100% Fertilizer	19.8	19.6	17.0	28.6	21.2	8.53	7.79	5.53	6.32	7.30s
100%Poulty Manure	15.6	15.9	16.0	16.7	16.1	8.11	6.09	11.17	8.24	8.40
75% Fertilizer + 25% Poultry Manure	14.6	20.6	14.6	16.0	16.4	4.04	9.08	6.06	7.84	6.75
50% fertilizer + 50% Poultry Manure	15.6	17.9	14.9	24.6	18.2	8.07	9.63	8.02	9.45	8.80
25% Fertilizer +75% Poultry Manure	14.1	19.9	15.7	16.0	17.3	7.78	11.17	11.23	9.08	9.82
Control	13.3	21.8	19.4	16.2	17.7	3.72	5.32	3.19	4.37	4.20
Means	13.9	18.8	15.6	20.4		6.71	8.35	7.53	7.55	

SED M 1.780.69
SED T 1.450.56
SED MxT 3.561.39

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