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EFFECT OF FERTILIZER MIXTURE AND TIME OF APPLICATION ON CROP ESTABLISHMENT AND ROOT YIELD OF SWEET POTATO IN AN ULTISOL OF SOUTH EASTERN NIGERIA.

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ABSTRACT:

A field study was carried out at National Root Crops research Institute Umudike in 2004 /2005 cropping seasons to determine the effect of the rate of nutrient mixture and time of application on crop establishment and root yield of sweet potato. The study involved the application of six rates of a mixture of poultry manure and inorganic fertilizer and four application periods on Sweet potato variety, Tis 87/0087. The results showed that application of 50% each of poultry manure and inorganic fertilizer (nutrient mixture) gave the best establishment of the crop (86.5 and 88.55% in both years) while time of application varied. In 2004, application at six weeks after planting gave higher root yield than two weeks after planting obtained in 2005 cropping season. Since there was no significant difference in root yield obtained between two and six weeks after planting for the two years and other parameters such as top yield root number were consistently higher at two weeks after planting , it is recommended that 50% each of such mixture be applied at two weeks for optimum establishment and root yield. Sweet potat.

Key words: Fertilizer mixture, Time of application, Establishment and Sweetpotato root yield.

INTRODUCTION

The use of organic manures had long been reorganized in the maintenance of organic matter status and in the amelioration of soil physical properties (Lal and Kang 1982). While inorganic nitrogen is easily leached from the soil, organic nitrogen is not readily leached or denitrified and its mineralization rate is dependent on many soil factors that affect plant growth, such as temperature and water availability (Kapland and Esther, 1985). The important factor in continuous productivity of tropical soil is the maintenance and improvement of physical characteristics. Once this is achieved, production capacity of these soils can further be improved by use of organic and inorganic fertilizer (Paul *et al.* 1993). Organic fertilizers have been used since ancient times and their influence on soil fertility has been demonstrated although their chemical composition and contribution of nutrients to crops and their effect on soil vary with their origin, age, handling and moisture content. Organic fertilizers can prevent, control and influence the severity of soil pathogens and can also serve be used to fertilize and improve soil fertility. Abawi and Thurston (1994) mentioned the influence of the organic manure on soil pathogens and pointed out a broad range of effects that depend on the material applied and degree of its decomposition. Interest in the sustainable cropping systems has focused renewed attention on the use of organic materials as fertilizers (Francis *et al.* 1977).Time of application and quality should be chosen in such away that as much as possible the nutrient is used by plants to ensure optimum crop use efficiency and minimize potential for the environmental pollution. Appropriate nutrient should be applied as near to the time the crops need them. This is of particular importance for the mobile nutrients such as nitrogen which can easily be leached out of the soil profile if they are not taken by plants (Chude *et al.* 2004). Soil fertility is one of the problems militating against maximum production of sweet potato in Nigeria. In the past, soil fertility had been maintained through long fallowing (Agboola and Unamma 1994).

Scientists are now shifting emphasis from use of inorganic fertilizer to complementary use of organic and inorganic fertilizer. Inorganic fertilizer is scarce and costly. The prices of fertilizer are shooting up day by the day Odigh (2007) Improved crop varieties make more demand of nutrients from

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the soil than the unimproved. The inorganic fertilizer recommendation of 60kgN 15kgP and 75kgK ha^{-1} to achieve high sweet potato yield in Nigeria farming systems has been found unsustainable (FFD 2002). Farmers prefer to substitute a proportion of the fertilizer requirement of the crops with organic manure which these farmers produce from their farming systems (Ano and Asumugha 2000) Appropriate time for the application of inorganic manure only or in combination with inorganic fertilizer has not been worked out for sweet potato varieties. These farmers still apply organic manure at the same time with inorganic fertilizer for all Sweetpotato varieties. Sweetpotato survival or establishment after planting is very relevant to recording the optimal yield of the crop. It is the established stand that ultimately accounts for the final yield. Sweetpotato is planted with vines and in most cases only two nodes are inserted into the soil. Unlike other root and tuber crops that depend on the food reserve, the vines only depend on the soil inherent or applied nutrient for survival. Making nutrient available to the crop is one of the basic considerations in Sweetpotato production that govern the timing of nutrient application (Brady and Weils 2002). To date there is dearth of information on the effect of time and rate of nutrient application on the crop establishment in relation to Sweetpotato. Therefore the objective of this study is to determine the effect of rate of fertilizer mixture and time of application on root yield of Sweetpotato

MATERIALS AND METHODS

The study was carried out at the eastern farm of National Root Crops Research Institute Umudike (NRCRI) during 2004 and 2005 cropping season. Umudike lies within the tropical rainforest zone with an annual rainfall of about 2000mm which is bimodal. The soil is classified acidic sandy loam rich in free iron and low in mineral reserve. The area was cleared, ploughed, harrowed and ridged mechanically. Soil samples were randomly collected with soil auger prior to planting at a depth of 0-15cm.All the soils were thoroughly mixed and a composite sample was obtained and analysed for some physco–chemical characteristics of the soil shown in table 1 The Sweetpotato used in this study is the cream-skinned white fleshed and prostrate growing NRCRI elite variety TIS87/0087 Four node vine cuttings were planted at the crest of the ridge of 1m apart at 30 cm between stands giving a population of 33,333 plants/ha. The trial was planted between 27^{th} and 29^{th} June in 2004 and 2005 respectively. The organic fertilizer used was poultry manure obtained from Michael Okpara University of Agriculture Umudike while the inorganic fertilizer was purchased from open market. The analytical result of the poultry manure showed that 3.2 tons /ha supplied an equivalent of 600kg NPK need of the crop at 60KgN, $15KgP_2{}^0{}_5$,$75KgK_20$/ha recommended for Sweetpotato production (FPPD 2002). Six combinations of inorganic fertilizer and poultry manure, namely, 450kg/haNPK+0.8tons/ha poultry manure (PM), 300kgNPK+1.6tons/ha PM, 150kg/ha NPK+2.4tons/ha PM, 600NPK, 3.2tons/ ha PM, and a control where nothing was applied, were evaluated over four application times 0(at planting), 2, 4, and 6 weeks after planting (WAP). The treatments were replicated three times in a Randomized Complete Block Design. The plot size was 6.0m x5.0m.

Maintenance of experimental plots

After planting the four node cuttings, gap filling was done after seven days to supply the vines that could not sprout. Weeding was done two weeks after planting manually before the Sweetpotato cover completely suppressed the weeds that lasted up till harvest. There was no severe incidence of pest so no pesticide was applied. Data were taken at the three inner ridges consisting of the net plot. The trial was harvested five months after planting. Both the underground roots and vines were used to assess the performance of the crop. Data collected were subjected to statistical analysis using mixed model of SAS programme (SAS1989)

RESULTS AND DISCUSSION

Physical and chemical properties of the soil

The physical and chemical properties of the soils of the experimental area in the 2004 and 2005 cropping seasons are shown in Table 1 In 2004. The pH (H_2O) in both experiments was slightly acidic 5.4, but in 2005 the pH was more acidic (4.7). This is in line with the description of the soil of the area as acid "sand" (Ojanuga 1996, Kamalu *et al* 1991 and Attoe and Amalu 2005). The soil in the previous year had been treated with inorganic fertilizer which could have resulted in this acidity (Aduayi *et al* 2002).

The level of phosphorous was lower in 2004 than in 2005 cropping season. This could be attributed to the previous use of the soil or cropping practices and processes of soil formation. Probably the previously applied soil amendment may not have been fully exhausted by the crops. The percentage nitrogen content of the soil in both years was relatively the same. The percentage of nitrogen during the 2005 was

a bit higher than in 2004, this could probably be due to previous cropping practices for nitrogen, such factors as leaching and denitrification could be responsible.

The percentage organic carbon in both years 2004 and 2005 differed slightly. What usually results in such variation is increase in soil organic matter according to (Opara-Nadi *et al*; 1987). The percentage organic matter in the soil during 2004 cropping season was less than in 2005 cropping season. Generally, the values of the chemical properties of the soils of the experimental area were less in 2004 than in 2005 except percentage base saturation and pH. This could be attributed to crop removal as yields were higher in 2004 than 2005 cropping seasons (Laura Van Scholl, 1998) or the nature of the crops and treatment applied to these two areas in the previous years. The effective cation exchange capacity in the soils was generally low (< 10.0cmol/kg^{-1}). This is a characteristic of low activity clays of the southe-astern Nigeria demonstrated by (Juo, 1981, Ojanuga, 1996 and Agbede, 1996). The low cation exchange capacity (CEC) of these soils indicated the poor ability of the soils to retain nutrients within the soils and hence facilitating high leaching rate (Agbede, 1996). The cation exchange capacity was dominated by exchangeable acidity as reflected in base saturation. This could be attributed to the high degree of weathering of soil and the high rainfall pattern of the area resulting in the displacement of the basic cations with acidic cations such as hydrogen and aluminium (Juo 1981). The lower base saturation in 2004 resulted in more acidic nature of the area. With mean value of 78% of sand, 11% silt and 17% clay, the soil for the area was classified as Typic Tropudult. Sandy soil is generally very porous with high infiltration rate, fragile and therefore easily prone to erosive forces (Enwezor *et al*, 1989 and Lekwa 1980). This could be responsible for the low yield of root crops especially sweet potato. The exceptionally low organic matter content of the soil in both 2004 and 2005 being below 20g ha^{-1} (Sys,C 1975) implies that there is need to add soil amendment material capable of improving the productive capacity of the soil more than 10gha^{-1}.Aune and Lal (1997) indicated that in soil with organic matter of less than 0.37% yields were reduced by 50%.

Table 1: Physical and chemical properties of soils of the experiment area (2004 and 2005)

Soil Parameters	2004	2005
pH(H_20)	5.4	4.7
P mgkg^{-1}	31.2	42.32
% N	0.08	0.09
% OC	0.71	0.79
% OM	1.22	1.36
CaCmolkg^{-1}	1.60	1.93
Mg "	1.20	0.93
K "	0.08	0.90
Na "	0.11	0.15
Ea "	0.96	0.96
ECEC "	3.96	4.09
% BS	72.50	75.75
% Sand	74	72
% Silt	10	11
% Clay	16	17
Texture	Sandy loam	Sandy loam

Table 2: Effect of fertilizer mixture of inorganic and time of application on establishment percentage of sweet potato in 2004 and 2005 cropping seasons.

	Time of Application (Weeks After Planting (T)									
	2004					2005				
Mixtures(M)	0	2	4	6	Means	0	2	4	6	Means
600Kg NPK	92.33	95.67	57.33	76.00	79.83	90.67	81.33	79.33	81.67	83.25
3.2tonsPM	99.33	96.67	55.33	57.00	77.03	84.33	90.00	87.67	79.67	85.42
450KgNPK+0.8tPM	96.00	97.33	45.33	95.33	83.50	85.67	83.33	83.00	87.67	84.92
300KgNPK+1.6tPM	95.00	97.33	57.67	96.33	86.58	89.67	88.33	87.00	89.33	88.58
150KgNPK+2.4tPM	98.67	54.33	68.00	97.00	79.50	85.00	76.33	86.33	79.67	81.83
Control	99.00	77.00	45.67	95.67	79.33	76.33	82.33	94.00	85.33	84.50
Means	96.22	86.38	54.88	76.82		85.28	83.61	86.22	83.89	
S.E.D.M					3.76					2.67
S.E.D T					3.07					2.18
S.E.D M x T					7.52					5.35

Table 3: Effect of fertilizer mixture and time of application on root yield t/ha of sweet potato in 2004 and 2005 cropping seasons.

	Time of Application (Weeks after Planting (T)									
	2004					2005				
Mixtures(M)	0	2	4	6	**Means**	0	2	4	6	**Means**
600KgNPK	19.8	19.6	17.0	28.6	21.2	8.53	8.79	5.53	6.32	7.30
3.2tPM	15.6	15.9	16.0	16.7	16.1	8.11	6.09	11.17	8.24	8.40
450KgNPK+0.8tPM	14.6	20.6	14.6	16.0	16.4	4.04	9.08	6.06	7.84	6.75
300KgNPK+1.6tPM	15.6	17.9	14.9	24.6	18.2	8.07	9.63	8.02	9.45	8.80
150KgNPK+2.4tPM	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	
S.E.D M		1.78	NS				0.69			
S.E.D T		1.45	NS				0.56	NS		
S.E.D M x T		3.56	NS				1.39	NS		

Establishment percentage

Table 2 shows the effect of the mixture of inorganic fertilizer and poultry manure and time of their applications on establishment percentage in 2004 and 2005 cropping seasons. The application of 300KgNPK+1.6tonsPM had the best mean establishment percentage in the two seasons. This was closely followed by the stablishment recorded at the application of 450Kg/haNPK+0.8tons/haPM. Highest percentage establishment of the crop was recorded at planting in 2004,(96.22) followed by the level of establishment at 2 Weeks after planting,(86.38) the least level of establishment was at 4 Weeks after planting. In 2005 the highest establishment percentage was recorded at 4WAP (86.22) followed by at planting (85.28) but the difference between the two was not statistically significant. The time of application and the interaction were very highly significant $p<0.001$. The highest establishment percentage recorded at the application of 300Kg/haNPK+1.6tons/haPM probably could be due to the contribution of the poultry manure in the mixture. In the 2005, highest percentage sprout was recorded at the application of 300Kg/haNPK+1.6tons/haPM, closely followed by the application of 3.2ton/ha PM, and 450Kg/haNPK+0.8tons/haPM. The rest were in the order of the control > 600Kg/haNPK > 150Kg/haNPK+ 2.4tons/haPM. Application at planting and 4 Weeks after planting were not significantly different from each other. Generally there was much difference in time of application over establishment percentages in 2005 cropping season. The treatments were not statistically significant in both time of application and the mixture. The application of 3.2tons of poultry manure may have also acted as mulch that may have created a conducive environment for root formation to aid establishment above every other application. Application at 2 Weeks after planting gave the least (83.6t/ha1) which was not significantly different from the others.

Mean root yield

The effect of mixture of inorganic fertilizer and poultry manure and time of application on root yield was not significant in 2004, (Table 3). However the result showed that application of 3.2tons/ha of inorganic fertilizer gave the highest mean root yield, which was closely followed by the application of 300Kg /haNPK+1.6tonsPM.The mean yield obtained at the control (17.7t/ha) appears to have been slightly greater numerically than the yield obtained from the rest of the treatments (16.1,16.4,and 17.3t/ha) apart from 600Kg/haNPK and 3.2t/ha 21.2t/ha and 18.2t/ha respectively. The yield obtained at the application of 3.2t/ha of inorganic fertilizer is at variance with the works of D"Sonza and Bourke (1986), Floyd *et al* 1988 and Priston, (1990), who observed higher sweetpotato root yield on application of combination of inorganic and organic fertilizer at Papua, New Guinea. This could be attributed to the inherent nutrient soil status. In terms of time of application, 6 weeks after planting gave the highest mean root yield which was not significantly different from the yield obtained at 2 weeks after planting. None of the rates of fertilizer mixtures and time had significant effect, even the interaction was also not significant. In 2005, the highest mean root yield was recorded at the application of 150Kg /haNPK+2.4t/haPM (9.82t/ha Table 3). This was closely followed by the application of 300Kg/haNPK + 1.6t/ha PM (8.80t/ha). This result is in agreement with the work of D"Sonza and Bourke (1986), Floyd *et al* 1988 and Priston, (1990) who credited their result to the various factors involved such as addition of beneficial nutrients in inorganic matter that are not found in inorganic fertilizer and the improvement in the physical and biological properties of the soil. Time of application of 2 weeks after planting gave the highest mean root yield 8.35t/ha closely followed by 6 and 4 weeks(7.55 and 7.53t/ha) after planting respectively. The least was recorded when fertilizer was applied at planting (6.71t/ha). The effect of fertilizer

mixture was highly significant ($P < 0.001$). This implies that the synergic effect of the two nutrient sources gave the best result while inorganic fertilizer easily releases the nutrient the poultry manure slowly releases its nutrient to sustain the growth and performance of the crops through the growing season, Onunka *et al*, 2003. The near uniform range of yield recorded by the time of application at 2 weeks after planting in the two year cropping season indicates that time of application of the mixture should be from 2 weeks after planting. This is implied since the ultimate aim of the farmers is optimum yield.

CONCLUSION

The result of this research has shown that nutrient sources and their time of application have effect on the crop establishment. The yield of any crop per hectare is usually extrapolated from final stand count and the area involved (population). In nutrient application studies, serious attention should be paid to its effect on crop establishment (survival), this is often neglected by researchers. This will help to realise the genetically actual crop yield.

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