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EFFECT OF POULTRY MANURE ON SOIL CHEMICAL PROPERTIES AND ROOT YIELD OF SWEET POTATO (*Ipomoea batatas* (L) LAM) GROWN IN A TROPICAL ULTISOL

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ABSTRACT

A field trial was conducted at National Root Crops Research Institute Umudike in 2004/2005 cropping seasons. The aim was to evaluate the effect of poultry manure applied over time intervals on some soil chemical properties and root yield of Sweet potato. The time intervals were 2 weeks before planting, (WBP), at planting, 2, 4, and 6 weeks after planting (WAP). Sweet potato varieties used were TIS 87/0087, TIS 5320 P. 1.13 and Ex-Igbariam. Poultry manure was applied at 3.2 t ha^{-1}. Results showed that application at 2 WBP, 6 WAP and at planting reduced soil pH in 2004 while in 2005 there was increase in PH. Also N, P, K, Ca, and Mg increased in both years. Application of poultry manure at 4WAP favoured the yield of varieties TIS 87/0087 and TIS2532OP.1 .13 while application at 6WAP favoured the root yield of Ex-Igbariam.

Key words: Soil, chemical properties, yield, sweet potato, varieties.

INTRODUCTION

The use of organic manures had long been recognized in the maintenance of soil fertility. The chemical composition and contribution to soil nutrient and crop growth and yield varies with age, handling and moisture content of the organic manures. Organic fertilizers can influence severity of soil pathogens and can also serve to fertilise and improve soil fertility. Abawi and Thurston (1994), reported the influence of organic manure on soil pathogens and pointed out a range of effects that depend on the materials applied and degree of its decomposition. The interest in the use of organic material as fertilizers has increased. Time of application and quality of manure are known to affect nutrient availability, use efficiency and the potential for environmental pollution. Appropriate nutrient should be applied to meet time dependent nutrient demand by crops. This is of particular importance for mobile nutrients such as nitrogen which easily leaches out of the soil profile if taken up by plants (Chude *et al.*, 2004)

There is uncertainly about fertilization rates for different sweet potato cultivars (Ankumah *et al.*, 2003). Nitrogen rates may range from 0-46 kg N ha^{-1}. Low soil fertility is one the problems militating against the maximum production of sweet potato in Nigeria. In the past, soil fertility had been maintained through land fallow (Agbola and Unamma 1994). Inorganic fertilizer is scarce and the cost is beyond the reach of resource poor farmers, this had limited its use for soil fertility maintenance. Sweet potato ranks as the 5th most important food crops in

developing countries after rice, wheat maize and cassava (Srinivas 2009). It is cultivated in 114 countries and ranks among the five most important food crops in over 50 countries (Srinivas 2009). In Africa, sweet potato is grown in upland lakes in East African rift valley, Uganda, Rwanda etc. but in Nigeria sweet potato is produced virtually in all the States.

There is dearth of information on the appropriate time of application of poultry manure and varietal specific response to manure application. Farmers apply poultry manure following recommendations for mineral fertilizers. Therefore, the objective of this study is to determine the effect of time of application for optimum root yield of sweet potato, varietal responses to manure application and effect on soil chemical properties.

MATERIALS AND METHODS

National Root Crops Research Institute Umudike is located within Latitude 4^0 15^1 and 7^0 N and 5^0 29^1 N and $7^0 33^1$E of the equator within elevation of 122m above sea level. The blocks used for this trial were maintained in a two-year rotation and in the penultimate year the blocks were planted with cassava. Soil fertility was enhanced with inorganic fertilizer application. The field was mechanically cleared, ploughed, harrowed, and ridged. The ridges were made at 1m apart in a plot size of 6m x 5m. After land preparation the soil samples were randomly collected, thoroughly mixed from which a composite sample was obtained and analyzed for the physico-chemical properties using standard methods. Four node cuttings of the two elite varieties and Ex-Igbariam (a land race) were planted at the crest of the ridges at 30cm intra and 100cm intra row spacing which gave a population of 33, 333 plants ha^{-1}. The poultry manure was sourced from Michael Okpara University of Agriculture Poultry Farm and cured for thirty days before application at the specified dates through broadcasting as recommended (Aduayi *et al.*, 2002*).* The design was Randomized Complete Block in a factorial experiment. There were fifteen treatments replicated three times. The trial was established in July each year and harvested after five months at maturity. Three soil samples were collected per plot for each treatment and analyzed. Sweet potato enlarged underground roots were harvested using digging fork according to treatments. From the measurements the corresponding yields in tons ha^{-1} were determined and analyzed with mixed model of SAS 1989 edition.

RESULTS AND DISCUSSION

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 mg kg^{-1}	31.2	42.32
% N	0.084	0.08
% OC	0.71	0.79
% OM	1.22	1.36
Ca cmol kg^{-1}	1.60	1.93
Mg	1.20	0.93
K	0.087	0.90
Na	0.113	0.15
Ea	0.96	0.96
ECEC	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

Soil pH.

The result of the effect of time of application of poultry manure on soil pH in 2004 and 2005 is shown in Table 2. Poultry manure applied at 2 weeks before planting, at planting and 6 weeks after planting reduced soil pH from 5.4 to 5.14 and 5.37 respectively. But application of poultry manure at 2 weeks after planting and 4 weeks after planting increased soil pH form 5.4 to 5.55 and 5.45. The reduction in soil pH at 2 weeks before planting may be due to depletion of soil nutrients especially the exchangeable cations and at 6 weeks after planting may be attributed to slow decomposition rate of added manure. This indicates that the time of application was not appropriate. The report of Duruigbo *et al. (2007*), lent support to these findings though they regarded the quantity of poultry manure used here as inadequate. The increased pH observed at 2 and 4 weeks after planting also agreed with the reports of Duruigbo *et al.* (*2007*). Jinadasa *et al.* (1997), observed reduction acidification and increased exchangeable cation when poultry manure was added to the soil.

In 2005, application of poultry manure increased soil pH across all time of application, but the highest increase was recorded at 4 weeks application from 4.7-5.7. The ability of organic manure to increase soil pH was due to the presence of basic cations contained in the poultry manure Natsher and Schwetnmann *(1991*), reported that such basic cations are released upon microbial decarboxcation.

Table2: Effect of variety and time of application of poultry manure on soil pH in 2004 and 2005 cropping seasons

Time of Application	**2004**				**2005**			
	V_1	**V_2**	**V_3**	**Means**	**V_1**	**V_2**	**V_3**	**Means**
T_1	4.84	5.3	5.54	5.23	5.78	5.21	5.74	5.57
T_2	5.46	5.29	5.36	5.37	5.32	5.60	5.86	5.59
T_3	5.62	5.62	5.41	5.55	5.21	6.25	5.58	5.68
T_4	5.43	5.46	5.47	5.45	5.52	5.81	5.82	5.72
T_5	4.78	5.16	5.47	5.14	5.74	5.33	5.90	5.66
Mean	5.23	5.36	5.45		5.51	5.64	5.78	
S.E.D. V		0.17					1.35	
S.E.D.Time		0.18					0.168	
S.E.D. V X T		0.29					0.28	

T1 = 2 weeks before planting (2WBP)
T2 = At planting (0WAP)
T3 = 2 weeks after planting (2WAP)
T4 = 4 weeks after planting (4WAP)
T5 = 6 weeks after planting (6WAP)

V1= TIS 87/0087
V2 = 2532.op.1.1.3
V3 = Ex-Igbariam

Soil Nitrogen

The result of time of application of poultry manure on percentage soil nitrogen is shown in table 3. The result revealed decrease in values of some N throughout the period of application in 2004. However, the least 0.05% was recorded for manure applied at 6 weeks after planting. This is in line with the work of Duruigbo *et al.* (2007), who observed highest reduction in organic carbon and total nitrogen from plots tested with organic fertilizer. This according to the authors was due to high nitrogen mineralization and nitrogen uptake by crops or loss through leaching. The reduction in soil nitrogen at 6 weeks after planting indicates a better match of soil nitrogen

sustainability and need by the crop. In 2005, a similar trend was observed with the least (0.05%) nitrogen recorded at 2 weeks and 4 weeks after planting.

Table 3: Effect of variety and time of application of poultry manure on soil Nitrogen in 2004 and 2005 cropping seasons (%)

	2004				2005			
Time of application	**V_1**	**V_2**	**V_3**	**Means**	**V_1**	**V_2**	**V_3**	**Means**
T_1	0.08	0.05	0.05	0.06	0.04	0.07	0.04	0.05
T_2	0.03	0.09	0.13	0.083	0.03	0.07	0.07	0.06
T_3	0.12	0.05	0.06	0.08	0.03	0.06	0.06	0.05
T_4	0.12	0.05	0.06	0.08	0.03	0.06	0.06	0.05
T_5	0.04	0.06	0.06	0.05	0.05	0.05	0.08	0.06
Mean	0.05	0.08	0.07		0.07	0.07	0.06	0.07
S.E.D. V		0.007				0.011		
S.E.D. Time		0.009				0.01		
S.E.D. V x T		0.01				0.02		

Soil Phosphorus

The result showed that in 2004 there was a general increase in the amount of soil available phosphorus across all time application. The highest soil phosphorus was recorded at planting application. Table 4, this was closely followed by application at 4 weeks after planting though both were not statistically different from the other. In 2005, the highest available phosphorus was recorded when poultry manure was applied at 4 weeks after planting. The critical need of potato for phosphorus is during the initial tuber formation. Sweet potato generally has low demand for phosphorus (Hahn and Hozyo, 1984) and the soil has a fair amount of phosphorus. Changes in available phosphorus were generally low.

Table 4: Effect of variety and time of application of poultry manure on soil phosphorous in 2004 and 2005 cropping seasons (Mg/kg^{-1})

	2004				2005			
Time of application	**V_1**	**V_2**	**V_3**	**Means**	**V_1**	**V_2**	**V_3**	**Means**
T_1	55.33	77.36	22.99	51.89	44.79	48.11	45.34	46.08
T_2	35.73	53.17	41.73	43.54	45.48	30.64	50.33	42.15
T_3	36.24	50.17	53.13	46.52	50.05	46.59	43.82	46.82
T_4	54.10	46.36	52.16	50.88	53.24	45.06	45.62	47.97
T_5	33.62	48.47	34.69	38.93	47.42	32.72	50.83	43.66
Mean	43.00	55.11	40.94		48.20	40.63	47.19	
S.E.D. V		6.65				8.70		
S.E.D. Time		7.75				8.43		
S.E.D. V x T		11.81				9.48		

Soil Potassium

The effect of time of application of poultry manure and varieties on soil exchangeable potassium is shown in table 5. In 2004 there was generally low level of exchangeable potassium in the soil however the highest value was recorded when manure was applied at planting. This was followed by application at 4 weeks after planting. In 2005, a similar trend was observed as soil exchangeable potassium was generally low, although the distribution was more uneven. However, the highest concentration was recorded for application at two weeks before planting followed by four weeks after planting. These concentrations were statistically different from the other ($P< 0.05$). The interaction between time of application and

variety was also significant. It appears more use of this mineral was made when poultry manure was applied immediately after the varieties were planted (0WAP) hence less of it was available at the end of the growing period.

Table 5: Effect of variety and time of application of poultry manure on soil potassium in 2004 and 2005 cropping seasons cmol/kg^{-1}.

	2004				2005			
Time of application	**V_1**	**V_2**	**V_3**	**means**	**V_1**	**V_2**	**V_3**	**means**
T_1	0.094	0.114	0.077	0.095	0.107	0.099	0.356	0.187
T_2	0.051	0.087	0.079	0.072	0.199	0.658	0.105	0.321
T_3	0.10	0.085	0.073	0.088	0.305	0.057	0.057	0.140
T_4	0.099	0.088	0.094	0.094	0.092	0.075	0.119	0.956
T_5	0.078	0.085	0.092	0.085	0.107	0.106	0.253	0.155
Mean	0.086	0.092	0.083	NS	0.162	0.199	0.178	
S.E.D. V		0.007				0.073		
S.E.D. Time		0.007				0.073		
S.E.D. V x T		0.012				0.073		

Soil Magnesium

In 2004, the result showed that there was generally an increase in quantity of soil magnesium compared to pre-planting value. Application at two WBP gave the highest quantity of soil magnesium; this was followed by 6 WAP. The least was recorded at the application on 0 WAP (Table 6).

In 2005, the highest soil magnesium was released at 2 WAP application, which was followed by 2 WBP and 6 WAP. The least was recorded at 0WAP application like in 2004, but the effect was generally not significant in all the parameters. It appears that time of application has no effect on the performance of the crop hence no significant difference was observed between the quantity available in the soil at crop maturity.

Table 6: Effect of variety and time of application of poultry manure on soil magnesium Cmol/kg^{-1} in 2004 and 2005 cropping seasons

	2004				2005			
Time of	**Variety**				**Variety**			
Application	**V_1**	**V_2**	**V_3**	**Means**	**V_1**	**V_2**	**V_3**	**means**
T_1	0.93	1.33	0.79	1.02	0.93	0.93	1.33	1.06
T_2	1.20	1.73	1.73	1.55	1.20	0.93	1.20	1.11
T_3	1.80	1.33	1.33	1.48	0.93	1.20	1.33	1.15
T_4	1.33	1.06	1.06	1.15	1.20	0.93	0.66	0.933
T_5	1.33	1.48	1.20	1.34	1.20	0.93	1.20	1.111
Mean	1.32	1.39	1.22		1.09	0.98	1.14	
S.E.D Variety		0.075				0.13		
S.E.D. Time		0.16				0.16		
S.E.D. V x T		0.16				0.26		

Soil Calcium

The result showed that the highest quantity of soil calcium was recorded at 2 WBP followed by application at 2 WAP Table 7. Others were 6 and 4 WAP and the least was application at 0 WAP. The result did not show any trend with regards to time of application probably as quantity of calcium was almost equal except at 0 WAP. According to Hartmiak (2003), this is presumably due to low output (removal) of soil calcium by sweet potato roots and vines indicating that the crop requires less soil calcium. According to Chude *et al.* (2004) Calcium mainly function as a constituent of cell wall in the form of calcium pectate necessary for normal mitosis, membrane stability and maintenance of chromosome structure amongst others.

In 2005, the highest was obtained at 2 and 6 WAP respectively. This was followed by application at 2 WBP and the least was at the application by 0 WAP. This result also agreed with the findings of Agbede *et al.* (2008), who observed an increase in soil organic matter, nitrogen, available phosphorus, exchangeable potassium, calcium and magnesium in Western Nigeria. Others with similar findings include Kingery *et al.* (1993) and Adeniyan and Ojeniyi (2005).

Table 7: Effect of variety and time of application of poultry manure on soil calcium cmol/kg^{-1} in 2004 and 2005 cropping seasons

	2004 Variety				2005 Variety			
Time of Application	**V_1**	**V_2**	**V_3**	**means**	**V_1**	**V_2**	**V_3**	**Means**
T_1	1.73	2.26	1.40	1.79	1.60	1.46	2.00	1.68
T_2	2.40	2.53	3.20	2.71	2.26	1.73	2.13	2.04
T_3	2.63	2.66	2.40	2.56	1.73	2.26	2.40	2.13
T_4	2.66	2.00	1.86	2.17	2.13	2.00	1.60	1.91
T_5	2.40	2.20	2.13	2.24	2.13	2.13	2.13	2.13
Mean	2.36	2.33	2.20	NS	1.97	1.92	2.05	NS
S.E.D Variety		0.18				0.26		
S.E.D. Time		0.23				0.29		
S.E.D. V x T		0.41				0.40		

Mean Root Yield

The effect of time of application of poultry manure on root yield (t ha^{-1}) of three varieties of sweet potato in 2004 and 2005 cropping seasons is shown on figure 1. In 2004, the result showed that varieties TIS87/0087 and TIS253.0p.1.13 recorded the highest root yield when poultry manure was applied at 6 WAP while Ex-Igbariam recorded its highest root yield at the application of poultry manure at 4 WAP. The three varieties recorded low root yield when poultry manure was applied 2 WBP. Generally, TIS2530p.1.13 out yielded the other two varieties and their yields were statistically different. Across the period of application, 4 WAP produced the highest root yield over the three varieties. In 2005, the result showed that varieties TIS87/0087 and TIS25320p.1.13 recorded the highest root yield at the application of poultry manure at 4 WAP. Variety three Ex-Igbariam recorded the highest root yield at the application of poultry manure 6 WAP similar to 2004. This implied that poultry manure application at 4 WAP favoured root production of varieties TIS87/0087 and TIS25330p.1.13 only, while 6 WAP favored root yield of Ex-Igbarim. This result is in consonance with the work of Onunka and Nwokocha (2003), who recorded varietal differences in sweet potato though not specifically on root yield. In 2005,

TIS2533.0p.1.13 recorded highest root yield over the various application times. This implied that, TIS2532.0p.1.13 made poor use of poultry manure applied between 2 and 6 WAP without negatively affecting root yield while Ex-Igbarim did well when poultry manure is applied at 6 WAP. The highest root yield recorded at 4 WAP implied that nutrient supplied was enough to provoke all machinery necessary for the transfer of photosynthates from source to sink for root formation. This result was also in line with the work of Nwinyi (1986), who recommended application of poultry manure for optimal root yield in sweet potato between 4-6 WAP. Low yield recorded in 2005 can be attributed to heavy rainfall, and according to Hartmink (2003). In wetter seasons, sweet potato yield are significantly reduced regardless of the cropping history of the soil Hartmink (2002), although high rainfall is beneficial for biomass and nutrient accumulation, it is detrimental during tuber initiation of sweet potato

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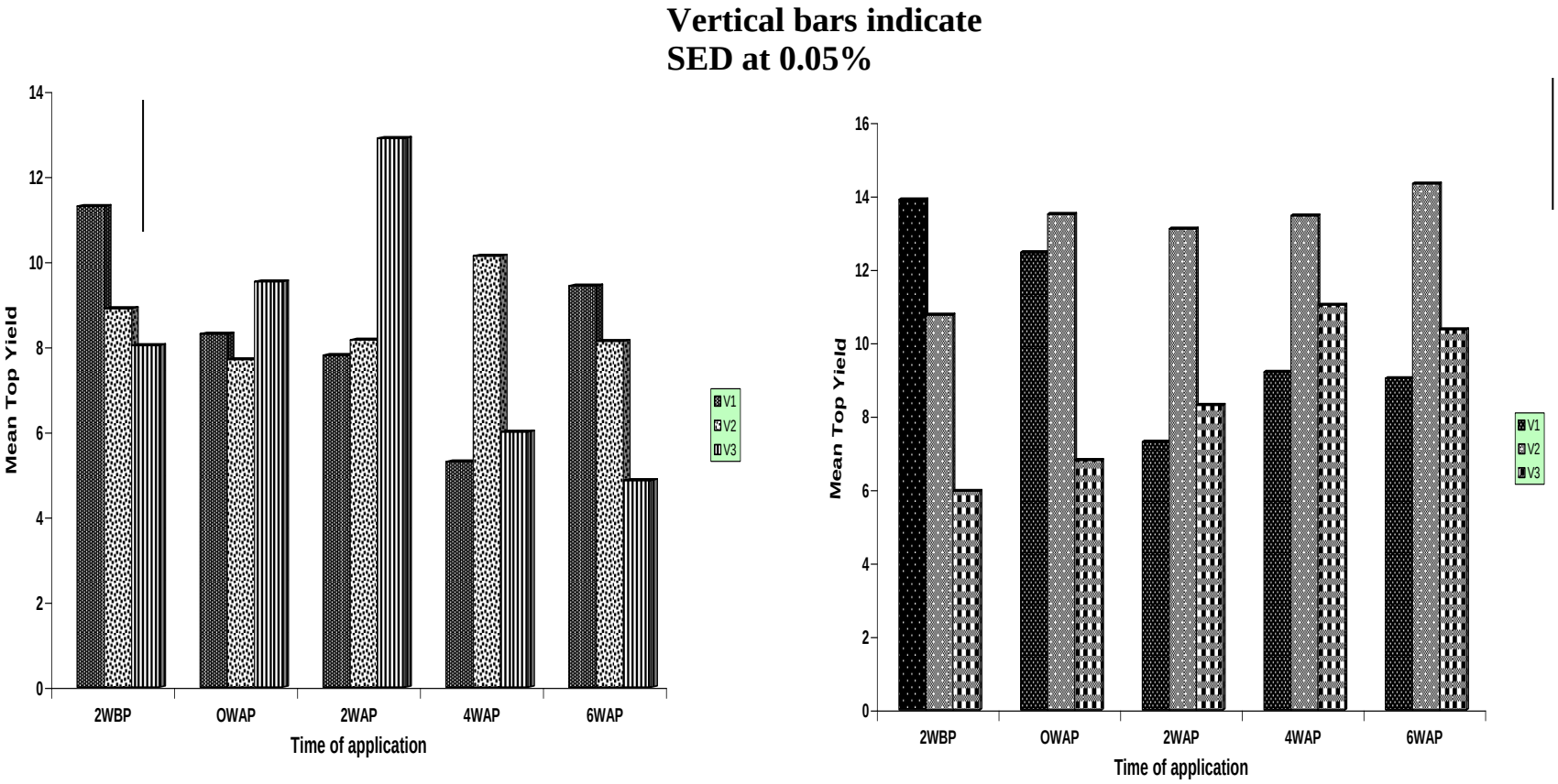


Fig. 1: Effect of time of application of poultry manure on mean root yield (t/ha) of three varieties of sweet p in 2004 and 2005 cropping seasons

CONCLUSION

The result showed that sweet potato exhibit varietal differences with regard to nutrient use in relation to time of application of poultry manure. It is not proper to apply poultry manure at the same period with inorganic manure. The relative decrease in soil nitrogen and potassium and increase in soil pH implies that poultry manure at the respective periods of application improved the soil chemical properties. The varied status of soil nutrient affected root production of the varieties of the sweet potatos tested. It is therefore, recommended that for optimum performance of the varieties of sweet potato application of nutrient source should not be across board. About 3.2 t ha^{-1} of poultry manure applied at 4 WAP is suitable for TIS87/0087 and TIS25320p.1.13 while 6WAP is suitable for Ex-Igbarim.

REFERENCES

Abawi, G. S. and Thurston H. D. (1994). *Effect de las cober tuvas yenconiendas organicas al guelo Y. las enfernedades radieallas una revision In: Tapados. Los systemas de siembracon cober tura. catieciifad Ithaca*, New York pp: 97 -108 In: *ppublicado lomo articulo en agrociencia* 34: 261 - 269 , 2000.

Adeniyan, O.N. and Ojeniyi S.O. (2005). Effect of poultry manure, NPK 15:15:15 and combination of their reduced levels on maize growth and soil chemical properties *Nigerian Journal of Soil Science*; Vol. 15: 34 – 41.

Aduayi, E.A., Chude, V.O. and Olayiwola, S.O. (2002). Soils of South Eastern Nigeria In: *Fertilizer use Management Practices for crops in Nigeria* pp 7.

Agbede, T. M., Ojeniyi, S.O. and Adeyemo A.J. (2008). Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum, Southwest Nigeria. *American-Eurasian Journal of Sustainable Agriculture* Vol. 7 (1) Pp 72-77.

Agboola, A.A. and Unamma, R.P.A. (1994). Maintenance of soil fertility under traditional farming systems. *Proc of National Seminar held at Kaduna* March 26 – 27. In FPPD FMA and NR Abuja.

Akanbi, D.I. (2005). Response of nutrient composition and yield component of tomato (*Lycopersicon esculentum*) to livestock manure. PhD thesis, Department of Crop, Soil and Pest Management. Federal University of Technology, Akure, pp 70.

Ankumah, R.O., Khan, V., Mwamba, K., and Kpomblekon, A. (2003). The influence and source and timing of nitrogen fertilizers on yield and Nitrogen yield efficiency of four sweet potato cultivars. *Agric. Ecos and environment* 100 (2003) 201 –207.

Chude, V.O., Malgwi, W.B., Amapu, I.Y. and Ano, A.O. (2004). Manual on soil fertility assessment FFP in collaboration with National Special Food Programme for Food Security NSPFFS Abuja Nigeria.

Duruigbo, C.I., Obiefuna, J.C, Onweremadu, E.C. (2007). Effect of manure rates on soil acidity in an ultisol. *Int. Journal of Soil Science* 2(2):154-258

Hahn, S. K. and Y. Hozyo (1984). Sweet potato In: P.R., Goldsworthy and N.M., Fisher (Eds). *The Physiology of tropical field crops*. John Willy and Sons N.Y., pp 551-567.

Hartmink A.E. (2003). Sweet potato nutrient dynamics after short farm fallows in the humid low land of Papua, New

Guinea ISTRIC World Soils Information P.O. Box 353 NL 6700 J. Wagengin the Netherlands.

Jinadasa, K.B. Mulhan P.N. Hawkins C.A., Cornish P.S. William P .A. Kaldo C.J. and Convoy J.P. (1977). Survey of cadmium levels in vegetables and soils of greater Sydney. *Aust. J. Soil Sci*, 22, 69 – 75.

Kingery, W.L. Carrwood W.L and Delany D.P. (1993). Impact of long term application of broiler litter on environmentally related soil properties. *Journal of Environmental Quality*. Vol. 23. pp 139 – 147.

Natsher J. and Schwetnmarn (1991). proton buffering in organic horizons of acid forests soils Ganddman 4.(8) 93-106

Nwinyi, S.O. (1986). Time of fertilizer application of optimum yield sweet potato *NRCRI Annual Report*. pp. 76.

Onunka, N.A. and Nwokocha, H.N. (2003). Varietal response of sweet potato (*Ipomoea batatas* (L) Lam) to different levels of nitrogen fertilization in tropical ultisol of South eastern Nigeria. *Journal of Sci and Tech Research*, vol 2 no 2, 2003.

Srinivas, T. (2009). Economics of Sweet potato production and marketing In: *The sweet potato*, G. Loebenstein, G. Thottappilly (eds.) pp. 235-267