EFFECTS OF POTASSIUM (K) SOURCES AND RATES ON TUBER YIELD AND STORAGE LIFE OF WHITE YAM (DIOSCOREA ROTUNDATA POIR) GROWN IN AN ULTISOL OF SOUTHEASTERN NIGERIA

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ABSTRCT

The effect of potassium (K) sources at two rates on tuber yield and storage life of white yam was investigated. The four sources of potassium were; defatted palm kernel cake (DPKC), poultry manure (PM), their combination (DPKC+PM) as organic K source and combined NPK fertilizer as inorganic K source while the two rates were 37.5 and 75.0kg K tha^{-1} (low and high rates) based on their K content and a control (no application). These treatments were laid out in a randomized complete block design (RCBD) with four replications and the test crop was a local land race (Nwopoko). Planting was in April (on-set of rain) while harvesting was done at seven months after planting (November) in both 2010 and 2011. Healthy tubers of varying grades were selected from each treatment for storage studies over a period of six months. While in storage, the tubers were examined periodically for weight loss, rot incidence, sprout development and dormancy period. Tuber yields and storage data were subjected to analysis of variance. Two years (2010/11) mean indicated that among K source, poultry manure at high rate showed significant difference to the control and had 41.67, 20.48, 24.50 and 28.84% increases over combined NPK fertilizer at similar rate on number large (>1kg), small (<1kg), total number and total tuber weight respectively. Utilization efficiency test further buttressed the superiority of K sources at both rates over the control. Tubers from defatted palm kernel cake plots enhanced the storage life of the white yam tuber by recording the least loss in weight, rot incidence and sprout weight of 27.00, 9.40 and 4.75% respectively, and the longest dormancy period of 95.5 days. From the result, it can be concluded that K sources at high rate proved more effective than low rate. Poultry manure had significant increase over the control and combined NPK fertilizer in the tuber yield attributes. Defatted palm kernel cake enhanced the storage life of the white yam tuber significantly ($P_{=}0.05$).

Keywords: Root and tuber, potassium, yam and utisol

INTRODUCTION

The present yam yield in the humid region of south-eastern Nigeria represents a small fraction of the potential yield due to low soil potassium (K) and nitrogen (N) reserve (Ohiri, 1990). Besides, yams being a high nutrient mining crop, needs higher amount of N, P and K with emphasis on K because of its importance in large tuber formation (Mengel and Rahmatullals, 1991). This is evidenced by 85 kg K being removed by yam harvest of 29.0 tha^{-1} while N and P were 133 and 10 kg respectively (Sobulo, 1972). Sanchez, (1976) observed that the low K level in soils of the humid tropics could be attributed to the intensity and duration of weathering which has resulted in vast areas being dominated by acid infertile soils characterized by low nutrient reserve, P-fixation, effective cation exchange capacity and suggested that this could be improved through the use of suitable organic inputs. Attempts to supply the required K level for yam through the application of organic materials could result in application of large amount of N. However, Obigbesan (1993) had suggested that N is a limiting nutrient in root and tuber crops production.

With the current shift to cassava as a cash crop and foreign exchange earner, it is envisaged that greater pressure will be placed on yams as the most important starch staple in Nigeria, hence the need to reposition yam production specifically as food security crop. Current feedback from farmers showed that yam production is still constrained by the following problems; inadequacies and untimely supply of inorganic fertilizer, post harvest losses due to pest and diseases. According to Ugwu (1995), loss of yam in storage may range from 30 – 66% of the total output in south-eastern Nigeria. There are also claims that yam tuber obtained from inorganic fertilizer fields were found to be more susceptible to weight loss in storage than those from unfertilized plots (Asadu et al., 2008). Ogaraku and Usman (2008) associated storage rot of yam to pathological deterioration. Sahore et al., (2007) observed that the dominant factor in determining how long the tuber can be stored is the length of the natural dormancy period.

It is based on this premise therefore that this study was deemed necessary with the aim of assessing the effects of organic and inorganic materials at different levels of their potassium content on yam tuber yield and storage life.

MATERIALS AND METHOD

Location

The study was carried out at the Research farm of National Root Crops Research Institute (NRCRI) Umudike (05^0 29^1N, 07^0 38^1E), with an annual mean rainfall of 2200 mm. The average monthly minimum and maximum temperatures range between 22 – 24 ^{0}C and 30 – 34 ^{0}C respectively in 2010 and 22 – 24 ^{0}C and 29 – 39 ^{0}C respectively in 2011. The mean monthly relative humidity being high during the wet season (60 – 80 %). Some properties of the soil are shown in table 1 while the mineral nutrient of the organic K source used for the study is shown in table 2.

Experimental Design

The treatment detail for the experiment is shown in table 3. The experiment was designed in a randomized complete block design (RCBD) with four replications. A plot size of 3m x 4m ($12m^2$) was adopted with a spacing of 0.75m between stands. The variety used was a local land race (Nwopoko) and the crop was planted in April (on-set of rain) in 2010 and 2011. Harvesting was done in November of both years. Crop production parameters were studied and analysed statistical (SAS 2000). K sources and rates utilization efficiency was determined by Tandon, (1987) method of measuring increment in crop yield per unit of fertilizer input given as

$$I.Y. = \frac{yf -}{yc} 1 \times 100 \text{ - - - - - - - - - - - - - - - } (1).$$

Where I.Y. = Increment in yield over control
yf = Yield from fertilized plot
yc = Yield from control plot
100 = Factor for conversion to percentage.

Storage Studies

A total of 72 tubers were selected and weighed (large (> 1kg) and small (< 1kg). Periodic checks were observed for weight loss, rot incidence, sprouting and dormancy period.

- ✓ Weight loss was obtained by the difference between the initial weight and successive weight divided by the initial weight. Multiplied by 100

$$\frac{\text{Initial Weight Successive Weight}}{\text{Initial Weight}} \times 100 \quad (2)$$

- ✓ Rot Percent was determined by dividing the number of tubers that rot with the total number of tubers stored and multiplied by 100

$$\frac{\text{Number of rot}}{\text{Number stored}} \times 100 \quad (3)$$

- ✓ Sprouting was evaluated visually for presence or absence of sprouts and recorded daily. Sprout relative weight percent was obtained thus

$$\frac{\text{Fresh Sprout Weight}}{\text{Fresh Tuber Weight}} \times 100 \quad (4)$$

- ✓ The duration of dormancy was calculated as given by Ireland and Passam, (1985) as 'the number of days from the start of storage to the first visible sign of sprouting'.

RESULTS AND DISCUSSION

In 2010 /11 (Table 4), K sources at high rate had higher mean values over their application at low rate on all the tuber yield attributes and were significantly (P=0.05) different to the control with over 50% increase except where the combined NPK fertilizer was applied at high rate that was statistically similar (less than 20.0% increase). The trend was similar in 2011, the depressed tuber yield notwithstanding. This indicated increased plant nutrient at high rate which was translated into increased tuber size, number and total weight. It also confirmed that there was synchrony between nutrients released and crop nutrient demand hence the efficiency of nutrient use (Mafongoya et al., 1998). Poultry manure treated plots at high rate had the highest two years average on number small, total number and tuber weight of 25.63, 31.63 per $12m^2$ and 18.10 tha^{-1} possibly on account of its organic nature (livestock waste) which when applied at the required quantity have the potential of supplying the required amount of N, P and K (Ahn 1970; Opara-Nadi et al., 1987). Secondly there are other secondary and micronutrient element that are inherent constituent of the organic waste which were not present in the other treatments (Essien et al 2010). Defatted palm kernel cake at high rate had the second highest mean values on tuber yield attributes and was consistently significant to the control in both year on number large (>1kg). This could probably be due to its high K content originally which Mengel and Rahmatullah, (1991) observed is specific in large tuber formation. K sources and rates utilization efficiency (Table 5) buttressed the efficiency of nutrient use over the control. In 2010, the increment percent relative to the control ranged between 119.40 and 221.89% while in 2011, it ranged between 101.85 and 183.64%. Poultry manure at high rate had the highest increment percent of 221.89 and 183.64% in both years followed by Defatted Palm Kernel Cake. Averagely (2010 and 2011) K sources at high rate of application recorded higher increment percent compared to low rate with the following corresponding values of 17.44, 10.04, 14.90 and 21.72% from defatted palm kernel cake, poultry manure, organic combination and combined NPK Fertilizer respectively. This implies that K sources enhanced the soil nutrients and base saturation of the degraded soil. According to Asadu, (1990); Ohiri and Chukwu, (1995), the capacity of soils to supply and absorb nutrient applied from fertilizer or amendments against leaching and erosion determines to a large extent the magnitude of crop yield. This was an indication that K sources at high rate have the potential to maximize yam tuber yield in the area. This observation agrees with the findings of Chukwu, (2007); Okore et al., (2007). The effect of K sources and rates on the shelf life of white yam tuber (Table 6) showed that the trend of response from treatments on the storage life of the white yam tuber in 2010/11 and 2011/12 were similar.

The highest and significant mean loss in tuber weight was obtained where poultry manure was applied at low and high rates with corresponding values of 34.33 and 36.40% in 2010/11; 36.72 and 39.70 in 2011/12 respectively. While defatted palm kernel cake at low and high rates had the least weight loss of 28.00 and 26.00% in 2010/11; 30.30 and 28.00% in 2011/12 respectively. This is traceable to the high nitrogen content in poultry manure (Table 2) and confirmed the finding of Asadu et al., (2008) that nitrogen is implicated in weight loss of the white yam tuber. Defatted palm kernel cake had the least weight loss possibly because of the balance between its N and K content (Table 2). Rot incidence showed high prevalence (20.00%) in 2010/11 and 25.00 in 2011/12 where poultry manure at high rate was applied. Defatted palm kernel cake at low and high rate had the least rot percent of 6.70 and 10.00% in 2010/11; 4.00 and 8.80% in 2011/12 respectively. This could be attributed to high amount of N in poultry manure which could cause protein hydrolysis and disintegration of membranes and finally tuber rot of the white yam in storage. This agrees with the work of Osuji and Umezurike, (1985).

Application of defatted palm kernel cake at high rate resulted in significantly longest dormancy period of 97.00 in 2010/11 and 91.00 days in 2011/12 followed by poultry manure and organic combination at similar rate with 90.00 each in 2010/11; 91.00 and 88.00 days in 2011/12. The control had the shortest dormancy period. Dormancy is known to be associated with low levels of glutathione and a group of growth inhibitors called batatasins. The longer dormancy period observed from organic K sources could be attributed to the fact these organic inputs are endowed with primary, secondary and micronutrient elements which could possibly influence the levels of glutathione and batatasins of the yam tuber and enhance dormancy contrary to the control. Asadu et al., (2008) made similar observation. On sprout weight, the control had the highest mean values of 7.40% in 2010/11 and 8.80% in 2011/12 while defatted palm kernel cake at low and high rates recorded the least sprout weight with the corresponding values of 5.00 and 4.80% in 2010/11; 6.20 and 4.70% in 2011/12. This is attributable to the shortest dormancy period which encouraged high vigour sprouts. Sprouting is a very active and energy demanding physiological process. This agrees with the findings of Ibrahim et al., (1987) and Schmutterer et al., (1980).

High rate application (75.0kg Kha^{-1}) recorded increased weight loss compared to low rate (37.5 kg k ha^{-1}) except at defatted palm kernel cake in 2010/11 and 2011/12. The trend was similar on rot percent and dormancy period without exceptions, possibly because of those factors explained earlier. The pattern changed on sprout weight of both years. High rate application recorded reduced sprout weight compared to low rate. This could possibly be due to long dormancy period and reduced rate of respiration and transpiration which resulted in reduced sprout vigour (Asadu et al., 2008).

CONCLUSION

The highest number of large (>1kg) yam tuber was obtained where defatted palm kernel cake was applied at 75.0kg Kha^{-1} (high rate) while the highest number small (<1kg), total number and total weight (tha^{-1}) was obtained from poultry manure at high rate.The utilization efficiency of K sources and rates proved superior to the control. Poultry manure at high rate was most effective. Yams grown with defatted palm kernel cake had the lowest weight loss and rot incidence percent, longest dormancy period (days) and least sprout weight percent. High rate (75kg Kha^{-1}) level of application is the better ratefor tuber yield and shelf life of the white yam tuber.

Table 1: Physical and Chemical Characteristics of the soil at 0 – 20cm Soil depth of the Experimental Site (NRCRI Umudike) before planting

Soil Characteristics	**2010**	**2011**
Sand (%)	80	74.2
Silt (%)	5	7.5
Clay (%)	15	18.3
Textural class	SCL	SCL
pH (H_20)	4.93	4.71
N %	0.07	0.05
Available P (mg Kg^{-1})	26.70	30.81
OC(%)	1.05	1.06
OM(%)	1.81	1.83
Ca(Cmol Kg^{-1})	1.20	1.20
Mg (Cmol Kg^{-1})	0.80	0.30
K (Cmol Kg^{-1})	0.10	0.08
Na (Cmol Kg^{-1})	0.09	0.13
EA (Cmol Kg^{-1})	1.60	1.3
ECEC (Cmol Kg^{-1})	3.79	3.01
BS(%)	57.8	56.80

Key: SCL = Sandy Clay Loam

Table 2: Mineral Nutrient and Organic Carbon Content of the Organic Manures used for the study

Parameters	Defatted Palm Kernel Cake (DPKC) (%)	Poultry Manure (PM) (%)
Calcium (Ca)	3.02	5.60
Magnesium (Mg)	0.49	2.03
Potassium (K)	1.60	0.70
Sodium (Na)	0.90	0.50
Phosphorus (P)	0.50	0.55
Nitrogen (N)	0.82	0.94
Organic Carbon (OC)	10.22	17.02
Organic Matter (OM)	17.62	29.34
C:N ratio	12:1	18:1

Table 3: Details of Treatments applied in the study

Treatments Nos	K sources/Rates	Quantity (t or Kg) ha^{-1}
1	DPKC R_1	2.34 t
2	DPKC R_2	4.68 t
3	PM R_1	5.36 t
4	PM R_2	10.72 t
5	DPKC + PM R_1	3.85 t
6	DPKC + PM R_2	7.70 t
7	NPK R_1	188.2 kg
8	NPK R_2	376.4 kg
9	Control	No Application

DPKC= Defatted Palm Kernel Cake, PM= Poultry Manure , DPKC+PM =Organic Combination (Defatted Palm Kernel Cake + Poultry Manure), NPK= Combined NPK Fertilizer, R_1= Low rate (45 kg N, 5 Kg P, and 37.5 Kg K), R_2= High rate (90 Kg N, 10 Kg P and 75 Kg K,) Control= No Application, $LSD_{(0.05)}$ = Least Significant Difference at 5% level.

Table 4: Effect of Treatments on White Yam Tuber Yield Characteristics in 2010 and 2011

Tuber yield characteristics

Treatments	**Number Large(>1kg) (per 12m^2)**	**Number Small(<1kg) (per 12m^2)**	**Total Number (per 12m^2)**	**Total weight t ha^{-1}**
		2010		
DPKC R_1	7.75^{a}	16.75^{b}	24.50^{bc}	19.30^{ab}
DPKC R_2	8.00^{a}	21.25^{ab}	29.25^{ab}	22.03^{a}
PM R_1	7.00^{ab}	18.00^{ab}	25.00^{bc}	20.23^{ab}
PM R_2	8.50^{a}	25.50^{a}	34.00^{a}	23.30^{a}
DPKC + PM R_1	6.75^{ab}	17.00^{b}	23.75^{bc}	15.63^{abc}
DPKC + PM R_2	7.25^{a}	22.50^{ab}	29.75^{ab}	20.60^{ab}
NPK R_1	4.25^{bc}	15.50^{b}	19.00^{c}	13.00^{bc}
NPK R_2	5.75^{abc}	19.00^{ab}	24.75^{bc}	16.30^{abc}
Control	3.00^{c}	15.00^{b}	18.00^{c}	10.05^{c}
LSD $_{(0.05)}$	2.77	7.57	7.36	8.67
		2011		
DPKC R_1	2.25^{abc}	18.00^{bcd}	20.25^{bc}	9.60^{abc}
DPKC R_2	4.50^{a}	20.75^{abc}	25.25^{ab}	12.15^{ab}
PM R_1	3.75^{ab}	21.50^{abc}	25.25^{ab}	11.98^{ab}
PM R_2	3.50^{abc}	25.75^{a}	29.25^{a}	12.90^{a}
DPKC + PM R_1	1.25^{bc}	19.75^{abc}	21.00^{bc}	11.30^{ab}
DPKC + PM R_2	3.75^{ab}	23.00^{ab}	26.75^{ab}	11.55^{ab}
NPK R_1	2.25^{abc}	15.00^{cd}	17.25^{cd}	7.60^{bc}
NPK R_2	1.25^{bc}	21.75^{abc}	23.00^{abc}	9.45^{abc}
Control	1.00^{c}	11.75^{d}	12.75^{d}	6.48^{c}
LSD(0.05)	2.57	7.27	7.44	4.56

DPKC= Defatted Palm Kernel Cake, PM= Poultry Manure , DPKC+PM =Organic Combinations (Defatted Palm Kernel Cake + Poultry Manure), NPK= Combined NPK Fertilizer, R_1= Low rate (45 kg N, 5 Kg P, and 37.5 Kg K), R_2= High rate (90 Kg N, 10 Kg P and 75 Kg K,) Control= No Application, LSD($_{0.05}$) = Least Significant Difference at 5% level.

Table 5: K- Sources and Rates Utilization Efficiency

Treatments	2010 Increment (%)	2011 Increment (%)	Mean (%)
DPKC R_1	182.02	132.72	157.40
DPKC R_2	209.25	172.07	190.66
PM R_1	191.34	169.44	180.39
PM R_2	221.89	183.64	202.77
DPKC + PM R_1	145.57	158.95	152.2
DPKC + PM R_2	195.02	162.81	178.92
NPK R_1	119.40	101.85	110.63
NPK R_2	152.24	130.40	141.32
SE	12.34	9.65	10.56

DPKC= Defatted Palm Kernel Cake, PM= Poultry Manure , DPKC+PM =Organic Combinations (Defatted Palm Kernel Cake + Poultry Manure), NPK= Combined NPK Fertilizer, R_1= Low rate (45 kg N, 5 Kg P, and 37.5 Kg K), R_2= High rate (90 Kg N, 10 Kg P and 75 Kg K,) Control= No Application, $LSD_{(0.05)}$ = Least Significant Difference at 5% level.

Table 6: Percentage Weight Loss, Rot Incidence, relative Sprout Weight and Dormancy Period (days)

Treatments	**Weight loss (%)**	**Rot (%)**	**Dormancy period (days)**	**Sprout weight(%)**
		2010		
DPKC R_1	28.00^{cd}	6.70^{d}	91.00^{b}	5.00^{a}
DPKC R_2	26.00^{d}	10.00^{cd}	97.00^{a}	4.80^{a}
PM R_1	34.33^{ab}	13.33^{bc}	88.00^{bc}	6.30^{a}
PM R_2	36.40^{a}	20.00^{a}	90.00^{b}	6.10^{a}
DPKC+PM R_1	31.40^{abcd}	13.33^{bc}	86.00^{bc}	6.40^{a}
DPKC+PM R_2	33.10^{abc}	16.60^{ab}	90.00^{b}	5.80^{a}
NPK R_1	30.30^{bcd}	6.70^{d}	80.50^{de}	7.10^{a}
NPK R_2	31.20^{abcd}	13.33^{bc}	84.00^{cd}	6.20^{a}
Control	30.00^{bcd}	11.25^{cd}	78.00^{e}	7.40^{a}
$LSD_{(0.05)}$	5.98	5.32	5.39	2.67
		2011		
DPKC R_1	30.30^{cd}	4.00^{g}	88.00^{abc}	6.20^{bc}
DPKC R_2	28.00^{d}	8.80^{e}	94.00^{a}	4.70^{c}
PM R_1	36.72^{ab}	12.60^{d}	83.00^{cde}	6.40^{bc}
PM R_2	39.70^{a}	25.00^{a}	91.00^{ab}	5.45^{bc}
DPKC+PM R_1	30.20^{cd}	6.70^{f}	84.00^{bcde}	6.80^{b}
DPKC+PM R_2	34.20^{bc}	20.00^{b}	88.00^{abc}	6.05^{bc}
NPK R_1	33.50^{bc}	8.33^{ef}	80.00^{de}	7.20^{ab}
NPK R_2	37.40^{ab}	18.00^{c}	85.00^{bcd}	6.75^{b}
Control	39.48^{a}	7.00^{ef}	77.00^{e}	8.80^{a}
$LSD_{(0.05)}$	4.63	1.85	7.31	1.89

DPKC= Defatted Palm Kernel Cake, PM= Poultry Manure , DPKC+PM =Organic Combinations (Defatted Palm Kernel Cake + Poultry Manure), NPK= Combined NPK Fertilizer, R_1= Low rate (45 kg N, 5 Kg P, and 37.5 Kg K), R_2= High rate (90 Kg N, 10 Kg P and 75 Kg K,) Control= No Application, $LSD_{(0.05)}$ = Least Significant Difference at 5% level.

REFERENCES

Ahn, P.M. (1970). West African Soils Vol. (1) Oxford University Press. Ely House, London W.I.

Asadu, C.L.A, and O.B. Egbobe and R. Asiedu (2008). Storage Life of Eleven Cultivars of White Yam (*Dioscorea rotundata*) Grown with or without Fertilizer and the Relationship with Residual Soil NPK Journal of Tropical Agric, Food Environment and Extension vol 7: (3), pp 234 – 240.

Chukwu, G.O. (2007). Soil Fertility Capability Classification for Seed Yam (Dioscorea Rotundata Poir) on Acid Soil in Southeastern Nigeria. Ph.D Thesis Submitted to Federal University of Technology Minna Nigeria.

Essien, B.A., J.B. Essien, J.C. Nwite, C.I. Keke, S.N. Okereke, J.U. Ogbu, and U.M. Anaele (2010). Evaluation of Organic Sources on Yam Performance and Weed Emergence in the Derived Savannah Proceeding of the 44th Conference of ASN Nigeria.

Ibrahim, M.H., J.O. Williams and M.O. Abiodum (1987). Assessment of Parts of Neem Tree for Yam Tuber Storage Rep. Nig. Stored Prod. Res. Inst. 4: 37 – 41.

Ireland, C.R. and H.C. Passam (1985). Effects of Exogenous Batatasins, Batatasin Analogues and Gibberellins on the Dormancy of Stored Tubers Tropical Agriculture 1985, 62: 41 – 45.

Mafongoya P.L.E:, K.E. Giller and C.A. Palm. Decomposition and nitrogen release pattern of tree prunings and littter. Agroforestry Systems 38: 77 – 97, 1998. Kluwer Academic Publishers Netherlands.

Obigbesan, G.O. (1993). Soil Nutrient Factors for Yam Production. In: Advances in Yam Research Production and Post-harvest Technology of the Yam Tuber G.O. Osuji (ed) Comparative Agricultural Centre, Prairie A and M Univ. Texas USA 2: 17-24.

Ogaraku, A. O. and H.O. Usman (2008) Storage Rot of Some Yams (Dioscorea Spp) in Keffi and Environs Nassarawa State Nigeria online at www.patnsukjournal.com/currentissue 4(2): 22 - 27.

Ohiri, A.C. (1990). Fertilizer Practices on Root and Tuber Crops in Nigeria. Proceeding Second National Fertilizer Workshop, Abuja, pp 50-57.

Ohiri, A.C. and G.O. Chukwu, (1995). Soil Physical and Chemical Conditions Favourable for Yam (*Dioscorea sp*) Growth and Tuber Development in Nigeria. Proceedings Third African Soil Science Society Conference, Ibandan, Nigeria pp 321-342.

Okore, I.K., P.O. Aiyelari and Eniola-Tijani (2007). Influence of Organic Manure and Mineral Fertilizer and their Combinations on Maize, Melon and Cassava Tuber Yield and Soil Characteristics in Southwestern Nigeria. Journal of Sustainable Agriculture and Environment. 9(2): 136-145.

Opara-Nadi, O.A.; B.S. Ezumah and A. Wogu (1987). Organic Manure and Inorganic Fertilizers added to an Acid Ultisol in southeastern Nigeria. II. Effects on soil chemical properties and Nutrient loss.

Osuji, G.O. and G.M. Umezurike, (1985). The Biochemistry of Yam tuber Determination In Advances in Yan Research. The Biochemistry and Technology of the Yam Tuber (G.Osuji ed) Biochemical Soc. of Nigeria/Anambra State University of Technology. Al-united Industries and Shipping Inc. Taiwan Publishers, Enugu 361 Pp.

Sahore, D.A., G.J. Nemlin and A. Kamenan (2007). Changes in nutritional properties of yam (*Dioscorea spp*) green plantain (*Musa spp*) and cassava (Manihot exculenta) during storage. Food Sci. Technol. 47: 81-88.

Sanchez, P.A., (1976). Properties and Management of Soils in the Tropics. New York: John Wiley and Sons.

Sobulo, R.A. (1972). Studies on White Yam Dioscorea Rotundata Poir. Growth Analysis. Expl. Agric. 8:99-106.

Statistical Analysis Softlarge (SAS) Institute, (2000) SAS Online Document Version 10 (online). Available @ *http://10 doc.sas.com/sashtm.SAS Inst.Cary.NC*.

Tandon, H.L.S. (1987). Phosphorus Research and Agricultural Production in India Fertilizer Development and Consultation Organization. New Delhi pp 160.