Niger. Agric. J. 31 (2000): 67-77

OPTIMIZATION OF K-FERTILIZATION AND HARVEST AGE OF FOUR SWEET POTATO *(IPOMOEA BATATAS (L) (LAM)* VARIETIES FOR FOOD TUBER YIELD IN A TROPICAL ULTISOL

P. A. OKWUOWULU and J. E. ASIEGBU

Department of Crop Science
University of Nigeria Nsukka.
(Accepted July, 2000)

ABSTRACT

The yield of fresh food tubers (weight and numbers), following different rates of K-fertilizer application and varying harvest ages of four sweet potato varieties was investigated at Umudike in 1997 and 1998. the varieties were TIS 8441, TIS 87/0087, TIS 2534 and Igbariam Local.

Tuber yield differed significantly among the four varieties. The highest yield of tuber was obtained with TIS 87/0087 in 3, 4 and 5 months after planting, while the lowest tuber yield was obtained with TIS 2534. significantly ($p = \leq 0.05$) yield increase of 2.5 fold was obtained in TIS 87/0087 by increasing harvest age from 3 to 5 months. Increasing k-level up to 175 kg/ha resulted in significant ($p = 0.05$) increase in the yield. Maximum yields were obtained from crops which received 175 kg ha-1 or 230 kg ha –1 of muriate of potash (k20) and harvested in 5 months.

Keywords: Sweet potato, harvest age, k-levels, food tuber yield, Tropical ultisol.

INTRODUCTION

Sweet potato (Ipomoea batatas (L) Lam) is an important staple in Africa, Asia and other tropical countries between 40°N and 40°S of the equator (Hahn, 1977; Alvarez, 1986; Okigbo 1986; Horton 1988). World output in 1985 was about 1.2×10^8 metric tones on 8×10^6 hectares (FAO,1985) with Asia accounting for more than 80% when compared with 15% from Africa (Scott, 1991). Nigeria had a negligible proportion: 0.2% of the world output (Nwokoach, 1992).

Sweet potato is regarded as a minor root crop in Nigeria and ranks fourth among root crops after cassava (Manihot sp.) yam

(Dioscorea sp), cocoyam (Colocasia sp and Xanthosoma sp), Ikwelle (1999). It was hitherto grown as a backyard crop or a crop best grown on the fringes of other crops, and fallen back on in time of famine. However, the current food need makes sweet potato presently important and is gaining in popularity particularly because it yields well and is of short duration (3-5 months). Hahn (1977) listed sweet potato to possess the highest energy fixing efficiency among 5 most important food crops in developing countries. The need to increase the cultivation is, therefore, important.

One method of achieving high production is application of appropriate fertilizer. In sweet potato cultural management, potassium fertilizer has been identified as a factor affecting tuber build-up hence Hahn (1977) reported that K-ions speed up activity of starch synthesis in the tuberous roots while Obigbesan (1980) reported that K-ions result in increased net assimilation and root yield. The normal k-rate (Enwezor et al. 1990) depends on agro-ecological zone.

There has been need to re-examine the fertilizer use efficiency. Hahn and Hozyo (1984) had recommended high k and low N (K:N) ratio as a method of boosting sweet potato production. This was sported by Nwinyi, et al (1987) who found that high N alone merely leads to excessive vegetative growth and causes mutual shading of leaves. CIP (1991) reported that adequate k application causes reduction in excessive vegetation due to N application.

The optimum age to harvest sweet potato for optimum quality tuber yield is also not well known. Currently, tubers are generally harvested at 4 months. However, varietal differences are there leading to maturity differences. Delaying harvesting predisposes tubers to infestation by field pests especially the sweet potato weevils, Cylas sp., leading to depressed yield and tuber of low market value. Yield losses due to delayed harvesting have not been quantified. Delayed harvesting also enhances preponderance of maturity cracks. On the other hand, pre-mature or too early harvesting leads to sub-optimal yield. Different varieties also vary widely in their maturity periods.

This study was, therefore, conducted to fill the gap in information on the fertilizer use, especially k-fertilizer,

study the effects of harvest age on the tuber yield in some sweet potato geno-types, and possibly ascertain yield losses due to prolonging the harvest age.

MATERIALS AND METHODS

The study was conducted in 1997 and 1998, at the eastern farm of the National Root Crops Research Institute (NRCRI), Umudike, (Latitude 05° 29'N; Longitude 07° 33'E and 122m above sea level). The soil is predominantly loamy sand. In 1997, planting was done on 22nd July and in 1998, on 16th July.

Treatments consisted of four varieties, viz: TIS 8441, TIS 87.0087, TIS 2534 and an Igbariam Local, chosen for their elite performance; three k-rates (115, 175 and 230 kg k/ha) and 3 three harvest ages (3, 4 and 5 months after planting). Factorial arrangement of the four varieties, 3 k-levels and 3 harvest ages constituted the 36 treatment combinations. These were laid in randomized complete block design and there were three replications. The varieties were allocated randomly as the main plots, while harvest ages were the sub-plots and the k-levels sub-sub-plot treatments.

Land preparation consisted of slashing, ploughing, and moulding into one metre ridges. Soil samples from a depth of 0-20cm were taken from different representative locations using soil auger. A composite sub-sample was then taken after thoroughly mixing the samples, and later subjected to physical and chemical analyses for characteristics of the field. Planting was done on ridges.

Each plot measured 4 ridges x 4.2m long with 1m between plots. The two inner ridges were the observational plots while the 2 outer ridges were the guard rows. Four node vines were planted on the crest of the ridges at 30cm within rows giving a population of 33000 plants/ha. Each plot received 98 kg N/ha as urea source and 83kg/ha single super phosphate as obtained through soil calibration analysis (Enwezor et al, 1990). The k-fertilizer (muriate of potash k_20) treatment was given at rates of 115 kg/ha which is the normal rate and served as control; 175 and 230kg k/ha given to appropriate plots. All fertilizers were applied at 4 weeks after planting. There were routine checks forthnightly for major pests, Cylas sp. Harvests were made at 3, 4 and 5 months after planting (MAP).

RESULTS

The soil characteristics (Table 1) showed low values for the pH, K, P and Mg, and medium values for N according to the criteria for classification of soil fertility of south-eastern Nigeria (Ibedu et al, 1988).

Table 1: Characteristics of the soil of the experimental sits

Physical property (%)		Chemical property	
		Exchangeable basis in Meg/100g soil.	
Clay	11.0	Na	0.01
Silt	2.0	K	0.003
Fine sand	50.0	Ca	0.6
Coarse sand	37.0	Mg	1.0
pH value		CEC	6.0
In H_2O	5.0	P (ppm)	3.4
In KCl	4.4	% base salt saturation	26.88
Textural class		Percentage	
Loamy sand		Organic matter	3.67
		Carbon	2.13
		Nitrogen	0.18

The weather during the study (Table 2) was normal for Umudike location being of the trend in the long-term (66 years) average.

Table 2: Climatic data for NRCRI station: Short and long term trends

	RAINFALL						TEMPERATURE						SUNSHIEN (HR)		
	1997 Amt (mm)	Days (no)	1998 Amt (mm)	Days (no)	66 yr. Av. Amt (mm)	Days (no)	1997 min.	Max.	1998 min.	max	66 Yr. Min.	Max	19971988		66 Yr.
Jan.	8.5	2	0.4	1	18.2	2	22	33	22	32	20	31	5.7	4.5	4.9
Feb.	0.0	0	1.8	1	39.9	3	20	35	24	36	21	33	5.6	4.5	4.5
March	65.7	6	35.6	5	120.8	8	23	34	24	35	22	32	3.5	2.3	4.7
April	198.1	11	114.2	9	196.8	14	23	32	25	34	23	32	4.9	5.6	5.0
May	320.9	14	311.3	18	266.0	17	23	31	24	33	22	32	5.7	6.9	4.9
June	349.2	22	402.6	21	272.8	20	23	30	23	31	21	29	4.2	5.4	4.2
July	279.5	17	243.2	21	296.1	22	23	29	23	30	22	28	3.5	2.9	2.6
Aug.	191.8	18	310.7	20	284.3	17	23	29	23	29	22	29	2.0	2.5	2.3
Sept.	231.5	19	287.6	23	333.4	24	23	30	23	29	22	29	3.5	2.5	2.7
Oct.	255.5	19	195.8	15	253.4	19	23	31	23	30	22	30	4.5	4.5	3.7
Nov.	108.7	8	70.1	3	70.6	7	23	31	23	32	22	31	4.5	5.5	5.3
Dec.	22.0	3	2.6	1	14.5	2	22	31	22	31	22	32	5.7	3.9	5.1
Total	2039.0	139	1975.9	138	2166.8	155									
Mean							23	31	23	32	22	31	4.4	4.3	4.2

Table 2b. The Climatic data showing the soil temperature in NRCRI, Umudike, in 1997 and 1998.

	Soil temperature							
	1997				1998			
	30cm		100cm		30cm		100cm	
	0900h	1500h	0900h	1500h	0900h	1500h	0900h	1500h
January	29.9°C	S32.2°C	30.7°C	30.8°C	27.6°C	29.9°C	29.0°C	29.1°C
February	30.0	32.5	30.7	30.8	31.8	34.1	31.3	31.4
March	30.2	32.3	31.2	31.3	31.5	33.7	31.9	32.1
April	28.8	30.4	30.2	30.2	30.8	32.8	32.0	32.0
May	28.5	30.0	29.9	29.9	29.4	31.5	31.0	31.0
June	26.6	28.7	29.1	29.1	28.0	29.8	30.0	30.1
July	26.9	28.5	28.7	28.0	27.5	28.7	29.3	29.3
August	26.3	27.9	28.0	28.0	26.6	27.9	28.3	28.3
Sept.	27.4	29.3	28.5	28.6	27.1	28.2	28.4	28.4
October	27.6	29.4	28.9	28.9	27.8	29.2	28.8	28.0
November	28.0	29.9	29.3	29.3	28.6	30.2	29.6	29.5
December	27.6	29.7	29.3	29.3	27.5	29.2	29.2	29.2

The decision to increase the k-level from the normal 115kg k20 was guided by the work of Hahn (1977) which showed that k-ions speed up activity of starch synthesis and Obigbesan (1980) who showed that k resulted in increased net assimilation rate and tuber yield.

In 1997, sweet potato food tuber yield was significantly highest in TIS 87/0087 followed by Igbariam Local and then TIS 8441 but rather low in TIS 2534 (Table 3).

Table 3: Effect of potassium fertilizer and harvest age on the yield of food tuber (t/ha) fresh weight in four varieties of sweet potato at Umudike

Variety	Fert-k (kg/ha)	1997 Harvest age (months) 3	4	5	Means	1998 Harvest age (months) 3	4	5	Means
TIS 8441	115	4.6	6.9	3.7	5.1	1.9	8.5	9.3	6.6
	175	4.7	9.0	11.6	8.4	3.4	12.5	11.3	9.1
	230	9.3	9.3	9.1	9.2	2.3	9.8	14.6	8.9
	Means	6.2	8.4	8.1		2.5	10.3	11.7	
Igbariam	115	0.5	11.3	14.1	8.6	0.0	6.2	1.6	2.6
	175	3.5	11.5	15.6	10.2	0.0	0.0	0.3	0.1
	230	4.1	10.3	15.3	10.0	0.0	0.4	1.0	0.5
	Means	2.7	11.0	15.1		0.0	2.2	1.0	
TIS 2534	115	1.2	1.9	4.2	2.4	0.3	2.2	3.6	2.1
	175	2.2	2.3	4.6	3.0	0.0	3.0	4.8	2.6
	230	1.6	3.1	4.6	3.1	0.0	5.4	3.4	2.9
	Means	1.7	2.4	4.5		0.1	3.5	4.0	
Harvesta age		4.7	9.0	11.2		2.2	8.1	8.0	

Overall fert-k mean (kg/ha K)	1997	1998
115	7.1	4.8
175	8.8	6.1
230	9.2	7.4

	1997	1998
S.E. of a diff for 2 Age or 2 k means	0.40	0.47
S.E. of a diff for 2 Variety (V) means	0.46	0.54
S.E. of a diff for 2 V x K means	0.79	0.94
S.E. of a diff for 2 V x Age means	0.79	0.94
S.E. of a diff for 2 K x Age means	0.68	0.81
S.E. of a diff for 2 Age of K x V means	1.37	1.63

Except for generally poor performance of Igbariam Local due to poor survival yield values followed similar trend in 1998.

Tuber yield always increased with increasing age at harvest from 3-5 months. Yield was significantly highest and economical with application of 175 kg k_20 ha^{-1} and harvested at 5 MAP.

TIS 87/0087 produced significantly greater number of food tubers in 1997 than TIS 8441 and TIS 2534 but not Igbariam Local (Table 4).

Table 4: Effect of potassium fertilizer and harvest age on the number of food tubers at harvest in four sweet potato varieties.

		1997 Harvest age (months)				1998 Harvest age (months)			
Variety	Fert-k (kg/ha)	3	4	5	Means	3	4	5	Means
TIS 8441	115	34510	30147	35700	33452	7535	35653	43237	28808
	175	28957	30147	31337	33183	13487	46807	46410	35568
	230	29353	39253	34907	34510	7933	32923	56327	32394
	Means	30940	36223	33981		96528	38461	48658	
Igbariam	115	41650	44030	49583	45088	00	379	8330	2909
	175	29353	48393	54343	44030	00	397	1190	5200
	230	21337	30543	45220	35700	00	3173	5157	2777
	Means	34113	40989	47915		00	1316	4893	
TIS 87/0087	115	38873	41253	48790	42972	19437	60690	49980	43369
	175	42840	42047	59500	48129	19437	63477	59377	44430
	230	41650	45617	45220	44162	19437	73385	65088	52634
	Means	41121	42972	57170		19437	65850	58148	
TIS 2534	115	11900	9243	12297	11147	1875	11913	34817	16035
	175	23800	13090	19833	18908	00	16563	29750	15471
	230	18247	16263	18643	17718	00	26180	29353	15811
	Means	17982	12865	16924		625	18053	31306	
Overall Means	Age	31039	33262	37947		7429	30930	35001	

Overall Means	fer-k	1997	1998
	115	33164.8	22780
	175	26062.4	23997.3
	230	33022.4	25904.2

	1997	1998
S.E. of a diff for 2 variety (V) means	1766.5	2016.9
S.E. of a diff for 2 potassium fert (K) means	1529.9	1746.7
S.E. of a diff for 2 harvest age (H) means	1529.9	1746.7
S.E. of a diff for 2 V x K means	3059.7	3493.4
S.E. of a diff for 2 V x H means	3059.7	3493.4
S.E. of a diff for 2 K x H means	2659.2	3025.4
S.E. of a diff for 2 V x K x H means	5299.6	6050.8

TIS 2534 produced significantly the lowest number of except that Igbariam Local gave a rather poor food tubers. Similar trends were maintained in 1998 establishment and did not produce harvestable food tubers at 3 months of age. In each year the number of tubers, on average, increased progressively with harvest age. Yield increase due to incremental application of k-fertilizer did not, however, attain significant level.

Varietal interaction with fertilizer k-level did not show significant effects within each variety and increasing fertilizer k-beyond 175 kg ha-1 did not appear advisable. TIS 2534 produced low tuber number irrespective of age at harvest and fertilizer level.

DISCUSSION

TIS 87/0087 was always the highest yielding variety in 3. 4 and 5 months. The yield difference by delaying harvesting from 3 to 5 months was 2.5 fold in the test varieties. This was in line with other recent results by Larbi et al. (1997) which reported that fresh root yield increased with maturity and cultivar 87/0087 had the highest root yield at 20 MAP in both Umudike and Otobi.

Increasing the rate of k-fertilizer application induced yield increase up to k-level of 175 kg ha^{-1} of k_20. earlier work by Nwinyi and Emezie (1984) recorded highest root yield with 140kg k/ha which was the highest k-level tested. Higher k_20 levels than 175kg/ha in the present work did not significantly increase tuber yield. Furthermore, increasing the rate of k-fertilizer application did not significantly increase the tuber number/ha. This confirms the report of Hahn and Hozyo (1984) that maximum tuber number was attained early in crop life. From the non-significant increase in tuber number with increase in k-level it was deduced that the role of k-was to increase the sink strength and capacity to accumulate starch when the starch synthatase activity speeds up. This deduction further compliments CIP (1991) report that k-application causes reduction in excessive vegetative (source) due to N application.

Significant yield variation obtained with varying cultivars was in line with the report of Larbi et al 91997) for fresh tuber yield of 18 sweet potato cultivars which Included 3 test cultivars of the present study: TIS 87/0087. TIS 8441 & TIS 2534. TIS 87/0087

was reported to possess high potential for root yield, (Anon, 1999) as similarly reported for food tuber in the present study.

There was no evidence of crop growth deficiency symptom as due to characteristics of the soil under the experimental conditions including the loamy sand as the textural class of the experimental site. These as well as the climatic data during 1997 and 1998 were of the long term (66 years) average and were condusive to sweet potato crop growth. Evidence of soil temperature effect on the tuber formation and yield has not been reported. From observation in the present study which obtained soil temperature within 0-30cm depth (tuber deposition zone) it was deduced that the temperature range, 26.3 –32.2oc during crop growth, was ideal for root tuber formation, bulking and ultimate yield. Further work was in progress.

The harvest age and fertilizer (k-level) did not result in loss due to field pests, hence tubers of poorer market value, as there was absence of pest infested tubers and absence of cracks on Tubers in both years. These were attributed to favourable crop weather especially rainfall (Anioke, 1996) which prevailed during the study years as well as the soil type (loamy sand) on which the trial was sited.

REFERENCES

ALVAREZ, N.N (1986) Sweet potato and African food crisis in: Tropical Root Crops. (Terry, ER; M.O. Akoroda and O.B. Arene eds) pp 66-69.

ANIOKE, S.C. (1996). Effect of time of planting and harvesting of sweet potato (Ipomoea batalas (L) Lam) on the yield and insect damage in southeastern Nigeria. Entomon 21 (2) : 137-141 (1996).

ANONYMOUS (1999) Characteristics of improved Sweet potato varieties In: Implementation Completion Report of the National Agricultural Research Project, National Root Crops Research Institute, Umudike, April 1999, pp. 23.

CIP (International potato center) (1991) Annual Report: (CIP 1990), Lima Peru. 258 pp.

ENWEZOR, W.O; A.C. OHIRI, C.E. OPAWARIBO and J.E. UDO (1990). Literature review on soil fertility investigation in Nigeria. Federal Ministry of Agriculture and Natural Resources, Lagos. pp. 78-79

FAO (FOOD AND AGRICULTURAL ORGANIZATIONS) (1985) The Year Book 1984 vol. 38, FAO, Rome 326 pp.

HAHN, S.K. (1977) Sweet potato. In: Ecophysiology of tropical crops. (eds. B. T. Alvin and T.T. kozlowski). Academic press, New York. Pp 237-246.

HAHN, S.K. and KOZOYO (1984). The physiology of Tropical Field Crops. Edited by P.R. Goldsworth and N.M.F. Fisher 1984. john Wiley & Sons Ltd. Pp.552-556

HORTON, D. (1988). Underground crops. Long-term trend production of roots and tubers. Winrock Inter. U.S.A. 22p.

IBEDU, M.A.; R.P.A. UNAMMA AND A UDEALOR (1988). Soil management strategies in relation to farming in southeastern

Agricultural zone of Nigeria. Paper presented at the Farming Systems Research Workshop, Jos Plateau State, Nigeria, 26-29 April, 1988. 20p

IKWELLE, M.C. (1999) Sweet potato. In: capabilities in Root and Tuber Crops Research and production. Paper presented at NRCRI. Annual Review and Research Workshop. 8-12 March, 1999. 5p.

LARBI, A; H. N. NWOKOCHA, J. W. SMITH, A. ANYANWU, L. D. GBARENEH, AND I. ETELA (1998). Sweet potato for food and fodder in crop livestock systems. ILRI-NRCRI Collaborative Research, 1997 Annual Report, 1-7.

NWINYI, S. C. O. AND J. F., EMEZIE 91984). Optimum N.P.K requirements of sweet potato (Ipomoea batatas) In: Cultural and soil requirement of sweet potato: NRCRI, Umudike Annual Report, 1984, pp. 236-238.

NWINYI, S. C. O.; S. O. ODURUKWE, AND J. E. EMEZIE (1987). Studies on optimum fertilizer requirements of sweet potato: proc. 5th Ann. Conf. SSSN. Pp. 120-126.

NWOKOACH, H. N. (1992). Root Crops Research and Technology Training Course (Training Manual) NRCRI, Umudike pp.77-84.

OBIGBESAN, G. O. (1980). Potassium response in root and tuber crops. paper read at the potassium Workshop Jointly organized by IITAa and International Potato Centre, Oct. 8-10, 1980, Ibadan, Nigeria.

OKIGBO, B. N. (1986). Root and Tubers in African food crisis. Keynote address. In: Tropical Root Crops. Proceeding of ISTRC-AB held in Owerri, Nigeria 17-23, Aug. 1986. E. R. Terry, M.O. Akoroda and O.B. Arene (eds) pp. 9-20.

SCOTT, G.J. (1991). Sweet potato as animal feed in developing countries; present patterns and future prospects pp. 138-188. Proc. Of FAO expert consultation held in CIAT, Columbia, 21-25 Jan., 1991. Edited by David Machin and solving Nyvoid.