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GROWTH AND YIELD RESPONSES OF SWEET POTATO (*IPOMOEA BATATAS*) TO TIME OF POTASSIUM FERTILZER APPLICATION

C.O. MUONEKE AND E.I. UKPE

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ABSTRACT

Two field experiments were conducted at the Michael Okpara University of Agriculture, Umudike research farm in 2005 and 2006 wet seasons to determine the growth and yield responses of two sweet potato (*Ipomoea batatas* L. Lam) varieties viz TIS 87/0087 and TIS 8164 to time of potassium (K) fertilizer application in a humid forest zone of south eastern Nigeria. In 2005 cropping season, the experiment was a 2 x 4 factorial laid out in a randomized complete block design with four replications. Potassium (K) treatments comprised no K application, 100 kg K ha^{-1} at 4 weeks after planting (WAP), 100 kg K ha^{-1} at 8 WAP, 50 K ha^{-1} at 4 WAP + 50 K ha^{-1} at 8 WAP. Time of K application had no significant effect on the growth attributes of the varieties, except in tuber dry weight and total dry matter plant^{-1} at 16 WAP where it was higher with split K application at 4 and 8 WAP in TIS 87/0087. TIS 87/0087 was significantly (P < 0.05) higher in total tuber yield when 100 kg K ha^{-1} was applied at 4 WAP and also with split application at 50 kg K ha^{-1} at 4 WAP + 50 kg K ha^{-1} at 8 WAP. In 2006 cropping season, a 2 x 8 factorial in randomized complete block design with three replications was conducted at the same location as in 2005. The treatments comprised of no K application, 100 kg K ha^{-1} at 2 WAP, 100 kg K ha^{-1} at 4WAP, 100 kg K ha^{-1} at 6 WAP, 100 kg K ha^{-1} at 8 WAP, 50 at 2 WAP + 50 kg K ha^{-1} at 6 WAP, 50 kg K ha^{-1} at 2 WAP + 50 kg K ha^{-1} at 8 WAP and 50 kg K ha^{-1} at 4 WAP + 50 kg K ha^{-1} at 8 WAP. Tuber and total dry weights were highest when K was split applied at 4 + 8 WAP but lowest when it was applied whole at 8 WAP. TIS 87/0087 was significantly (P < 0.05) higher in tuber yield ha-^{1} when K was split applied at 2 WAP + 6 WAP or 50 kg K ha^{-1} at 4 WAP + 50 kg K ha^{-1} at 8 WAP. TIS 87/0087 which is a higher yielding variety is recommended for the study area with split application of K at 2 WAP + 6 WAP or at 4 WAP + 8 WAP.

KEY WORDS: Sweet potato, *Ipomoea batatas*, K, time of K application.

INTRODUCTION

Sweet potato (*Ipomoea batatas*) L. Lam) is a widely grown and an important staple food crop in most parts of tropical and subtropical regions of the world and ranked 7th among the world's major food crops (FAO, 2004). Within the sub-Saharan Africa, it is the third most important root and tuber crop after cassava and yam (Hahn and Hozyo, 1998). Of the 45 genera and 100 species in the family Convolvoluceae, only *Ipomoea batatas* is of economic importance as food (Edmond, 1971).

The increasing potential of the crop in poverty alleviation and food security due to its high productivity per unit area and time makes sweet potato an important crop for the survival of the resource poor farmers in Nigeria (NRCRI, 2003). The crop serves as a starch staple food for human consumption. The tuber can be eaten roasted, fried or boiled (NRCRI, 1985). The foliage and smaller tubers serve as livestock feed (Ambe- Tumanteh, 1994). Its importance in starch, alcohol, pharmaceutical and textile industries is widely recognized (Woolfe, 1992). The orange-fleshed varieties with high ß-carotene content have become very important in combating vitamin A deficiency, especially in children (Woolfe, 1992). Sweet potato has a high nutritional value and serves as a good source of energy, calcium, iron, vitamins and some minerals (Woolfe, 1992). The leaves are rich in protein, with 34.5% crude protein (Nwinyi, 1987). Sweet potato roots can be reconstituted into *fufu* or blended with other carbohydrate flour sources such as wheat and used for baking bread and biscuits (Udoh *et al*., 2005). However, about 80% of the crop produced in Nigeria is used for human food (FAO, 2005).

Low soil fertility is one of the constraints in production of sweet potato in Nigeria. In the past, soil had been maintained through long fallow periods (Agboola and Unanma, 1994) but presently, due to population pressure as well as urbanisation and industrialisation, fallow periods have been reduced from 10 years to 1-2 years, resulting in declining crop yield (IITA, 1993). Fertilizer application is an important option left to farmers for yield improvement in most soils. The potential of sweet potato as a cash crop has led to the requirements of fertilizer recommendations for commercial farmers to increase root yield. Continuous cultivation of farm lands leads to depletion of soil nutrients, including K. Successive harvests remove large quantities of K from the soil and if the element is not sufficiently replaced by fertilization, the soil would be deficient in K.

In sweet potato cultural management, K fertiliser application has been identified as a factor affecting tuber bulking and yield (Hahn, 1977). Potassium ions promote starch synthesis in tuberous roots. Potassium fertiliser influences tuber quality and plays a significant role in increasing the rate of photosynthesis (Hahn and Hozyo, 1984). Potassium application causes reduction in

C.O. Muoneke, Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia, Nigeria.
E.I. Ukpe, Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia, Nigeria.

excessive vegetative growth following high nitrogen application (CIP, 1980). Use of K has also been associated with reduced disease resistance. Jackson *et al*. (1982) reported reduction in the incidence of stem rot (*Erwinia carotovora*) with K fertiliser treatments.

Some work had been carried out on different rates of K fertiliser to improve tuber yield of sweet potato but research information on time of K application for optimum yield of the crop is scanty. The objectives of the present study being reported were to evaluate the yield of two important sweet potato cultivars under the humid forest conditions and to determine the efficiency of single or split K fertiliser application and when to apply the fertiliser.

MATERIALS AND METHODS

Two field experiments were conducted in 2005 and 2006 wet seasons at the Michael Okpara University of Agriculture, Umudike Teaching and Research farm. Umudike is located at 05˚ 29´ N, 07˚ 33´ E and 122 m above sea level and situates in the humid tropical lowlands of south eastern Nigeria. The soil of the location is sandy loam and the site is in area of high rainfall with temperatures between 22 and 33° C and relative humidity of 75 -85 % .

The experimental site had been previously under cassava crop but was under a two-year bush fallow prior to land preparation. The experimental site was slashed and land preparation done by conventional tillage with disc plough and later harrowed twice with disc harrow. One meter wide ridges of 3 m length were prepared. Soil samples from 0-20 cm depth were collected from different representative locations of the experimental area with soil auger. They were bulked into composite sample, air dried, sieved through a 2 mm sieve and their physical and chemical properties determined before planting.

Experiments I and II were conducted in 2005 and 2006 wet seasons, respectively during June to October months of the years.

Two Tropical Ipomoea Selection (TIS) sweet potato varieties, TIS 87/0087 and TIS 8164 were used for the experiments. TIS 87/0087 is characterized by trailing vine and light pinkish roots with cream coloured flesh and with rare flowering, while TIS 8164 is characterized by bunchy, erect vine with deep pinkish roots and conspicuous pinkish flowers (Larbi *et al*., 1997).

The experiment was a 2 x 4 factorial in randomised complete block design with four replications in the 2005 cropping season. The plot size was 4 m x 3 m (12 m^2). The potassium (K) fertiliser treatments were: 0 kg K, 100 kg K/ha at 4 weeks after planting (WAP), 100 kg K/ha at 8 WAP, 20 kg k/ha at 4 WAP + 50 kg k/ha at 8 WAP. The sweet potato treatments were TIS 87/0087 and TIS 8164.

In 2006, a 2 x 8 factorial experiment was conducted using the same sweet potato varieties as in 2005 and the K treatments were : 0 kg K, 100 kg K/ha at 2 WAP, 100 kg K/ha at 4 WAP, 100 kg K/ha at 6 WAP, 100 kg K/ha at 8 WAP, 50 kg K/ha at 2 WAP + 50 kg K/ha at 6 WAP, 50 kg K/ha at 2 WAP + 50 kg K/ha at 8 WAP, 50 kg K/ha at 4 WAP + 50 kg K/ha at 8 WAP. In each cropping, K fertiliser was applied as muriate of potash. Each plot received blanket application of 80 kg (Njoku, 2000) at the initial time of treatment application.

Sweet potato vine cuttings of 20 cm long were planted at a spacing of 1. 0 m x 0.3 m along the crest of the ridge on 18 June, 2005 and on 22 June, 2006. The 1.0 m x 0.3 m spacing gave a plant population of 33, 330 plants/ha. Two manual hoe weedings were done at 4 and 8 WAP.

Two plants were randomly selected from the inner rows and tagged and data taken on vine length (longest vine), number of leaves per plant, leaf dry weight, vine dry weight, tuber dry weight and total biomass (total dry matter), all at 10 WAP and 16 WAP. Yield and yield components (number of marketable, unmarketable and total number of tubers/m^2 as well as weight of marketable, unmarketable and total tuber yield/ha) were taken at 16 WAP when the leaves had turned yellowish and had started dropping. Marketable tubers were equal to or greater than 100 g while unmarketable ones were those that weighed less than 100 g (Njoku, 2000). Early harvesting was done to avoid *Cylas puncticollis* damage.

The data for each year were subjected to analysis of variance following the procedures outlined by Gomez and Gomez (1984) and Obi (1986) for a factorial experiment in randomised complete block design with treatment means differences tested for significance using Fisher's protected least significance difference (F-LSD) at $P \leq 0.05$). The data were analysed using Genstat statistical package (Genstat, 2003).

RESULTS

The physico-chemical analyses of the soil of the experimental sites were in case sandy loam with low to moderate nutrient contents (0.07 – 0.10% N, 17.4 – 18.49 mg/kg P and 0.11 – 0.19 mg/kg K) (Table 1).

Growth:

There were no significant differences ($P > 0.05$) in the number of leaves per plant and vine lengths of TIS 87/0087 and TIS 8164 sweet potato varieties in both 2005 and 2006 cropping seasons (Table 2). Also there was no effect of time of K application on the number of leaves per plant and vine length in both years, except that in 2006cropping season, the number of leaves was highest with applying all the K fertilizer at 4 or 6 WAP and lowest with split application at 2 + 8 WAP or 4 + 8 WAP. Leaf dry weight per plant was not affected by sweet potato variety nor time of K application in 2005 and 2006. In 2005, tuber and total dry weights as well as harvest index were higher in TIS 87/0087 than TIS 8164 (Table 3). Also in 2006, TIS 87/0087 had higher leaf and vine dry weights but lower harvest index than TIS 8164.

In 2005, there were no effects of the time of K application on vine and total dry weights as well as harvest index. In 2006, vine dry weight was higher with application of all the K fertilizer at 4, 6 or 8 WAP or with split application 2 + 8 WAP whereas it was least with split application at 2 + 6 WAP. The tuber and total dry weights per plant as well as the harvest index were highest with applying half of the K at 4 WAP and the other half at 8 WAP. The lowest values for tuber and total dry weights as well as HI were when all the K was applied at 8 WAP (Table 3).

Yield and yield components:

The interaction of sweet potato variety and time of K application showed that TIS 87/0087 had higher number of marketable and total tubers/m^2 at all K applications in 2005 (Table 4). However, the number of marketable and total tubers/ m^2 were highest with TIS 87/0087 that received all the 100 kg K/ha fertilizer at 4 WAP. At zero K and split K application, TIS 87/0087 had more than one and half times the number of marketable and total number of tubers /m^2 than TIS 8164 variety, especially when all the K was applied at 4 or 8 WAP. Similarly, TIS 87/0087 variety produced the heaviest marketable and total tubers/ m^2 when all the K was applied at 4 WAP (Table 5). In TIS 8164 variety, the weight of marketable tubers and total tubers yield/ha were higher when K was split applied at 4 + 8 WAP than when all the K was applied at 8 WAP. In TIS 87/0087, there was no effect of time of K application on tuber yield/ha. Whether K was applied once or split, TIS times the values, especially when all the K was applied at 4 or 8 WAP.

In 2006 cropping season, TIS 87/0087 still performed better than TIS 8164 variety for number of marketable and total tubers/m^2 as well as marketable and total tuber yield/ha (Table 6). There was a significant ($P > 0.05$) difference between the two varieties for number of unmarketable tubers/ m^2. When all the K fertiliser was split applied at 2 + 6 WAP or 2 + 8 WAP, the number of marketable and total tubers/ m^2 were higher than whole application at 2, 6 WAP or no application. The time of K application significantly ($P < 0.05$) influenced yield and yield components (Table 6). Marketable and total tuber yields were highest with split K application at 2 + 6 WAP or 4 + 8 WAP and least with 0 and the whole 100 kg k/ha application at 2 WAP. The result also showed that the total tuber yield was higher in all cases of K application compared to where K was not applied.

Table 1: Some physical and chemical characteristics of the soil of the experimental sites in 2005 and 2006 cropping seasons

Soil characteristics	2005	2006
Physical		
Sand (%)	75.8	76.3
Silt (%)	3.9	3.7
Clay (%)	20.3	20.1
Textural class	Sandy loam	Sandy loam
Chemical		
Soil pH (1:2.5 soil: H_20)	4.61	4.66
Organic carbon (%)	1.17	1.23
Organic matter (%)	2.98	2.22
Total N (%)	0.07	0.10
Available P (mg kg^{-1})	17.4	18.49
Exchangeable K (cmol kg^{-1})	0.11	0.19
Ca (cmol kg^{-1})	0.50	0.48
Mg (cmol kg^{-1})	0.65	0.63

Table 2: Number of leaves/plant and vine length (cm) of two sweet potato varieties as influenced by time of K application at 10 WAP in 2005 and 2006 cropping seasons

	No. of leaves/plant		Vine length (cm)	
	2005	2006	2005	2006
Sweet potato varieties				
TIS 87/0087	91.1	175.4	69.8	75.9
TIS 8164	84.6	171.0	79.6	84.6
$LSD_{0.05}$	ns	Ns	ns	ns
Time of K application				
No application	78.8	165.5	71.6	111.1
100 kg K/ha at 2 WAP	-	181.6	-	116.9
100 kg K/ha at 4 WAP	95.7	207.8	78.6	114.5
100 kg K/ha at 6 WAP	-	209.1	-	158.4
100 kg K/ha at 8 WAP	81.2	197.5	65.3	144.3
50 kg K/ha at 2 WAP + 50 kg K/ha at 6 WAP	-	146.6	-	119.8
50 kg K/ha at 2 WAP + 50 kg K/ha at 8 WAP	-	137.0	-	138.9
50 kg K/ha at 4 WAP + 50 kg K/ha at 8 WAP	95.7	140.5	82.3	137.8
$LSD_{0.05}$	ns	70.9	ns	ns

Table 3: Dry matter distribution in tw6 sweet potato varieties as influenced by time of K application at 10 WAP in 2005 and 2006 cropping seasons

	Leaf dry wt (g/plant)		Vine dry wt (g/plant)		Tuber dry wt (g/plant)		Total dry wt (g/plant)		Harvest index	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Sweet potato varieties										
TIS 87/0087	12.1	48.8	24.5	50.5	99.3	148.0	136.3	247.3	0.68	0.55
TIS 8164	10.7	26.8	28.5	27.4	54.6	180.0	94.0	234.2	0.53	0.73
$LSD_{0.05}$	ns	13.8	ns	8.10	35.0	ns	42.0	ns	0.11	0.89
Time of K application										
No application	11.7	40.3	28.7	31.7	61.4	105.0	102.0	177.0	0.60	0.53
100 kg K/ha at 2 WAP	-	34.6		35.4	-	167.0	-	237.0	-	0.70
100 kg K/ha at 4 WAP	9.7	31.6	24.0	44.8	91.5	171.0	125.0	247.0	0.66	0.65
100 kg K/ha at 6 WAP	-	49.6		43.5	-	133.0	-	227.0	-	0.55
100 kg K/ha at 8 WAP	11.9	43.7	25.5	44.7	49.7	62.0	87.0	151.0	0.54	0.41
50 kg K/ha at 2 WAP + 50 kg K/ha at 6 WAP	-	45.7	-	26.9	-	222.0	-	295.0	-	0.76
50 kg K/ha at 2 WAP + 50 kg K/ha at 8 WAP	-	31.6	-	44.8	-	198.0	-	274.0	-	0.72
50 kg K/ha at 4 WAP + 50 kg K/ha at 8 WAP	12.2	25.2	28.6	39.8	105.1	248.0	146.0	311.0	0.67	0.77
$LSD_{0.05}$	ns	ns	ns	16.4	49.5	106.0	ns	122.0	ns	0.18

Table 4: Interaction effects of sweet potato varieties and time of K application on the marketable and total number of tubers/m^2 in 2005 cropping season

	Time of K application			
	No K application	100 kg K/ha at 4 WAP	100 kg K/ha at 8 WAP	50 kg K/ha at 4 WAP + 50 kg K at 8 WAP
Sweet potato varieties				
Number. of marketable tubers/m^2				
TIS 87/0087	2.8	5.5	4.3	3.7
TIS 8164	2.7	1.9	1.3	2.6
Total number of marketable tubers/m^2				
TIS 87/0087	4.3	8.2	6.8	6.0
TIS 8164	3.1	2.3	4.2	3.5
		Number. of marketable tubers/m^2		Total number of marketable tubers/m^2
$LSD_{0.05}$		1.5		2.1

Table 5: Interaction effects of sweet potato varieties and time of K application on the weight of marketable (t/ha) and total tuber yield (t/ha) in 2005 cropping season

	Time of K application			
	No K application	100 kg K/ha at 4 WAP	100 kg K/ha at 8 WAP	50 kg K/ha at 4 WAP + 50 kg K at 8 WAP
Sweet potato varieties				
Weight of marketable tubers (t/ha)				
TIS 87/0087	4.7	11.9	8.8	9.0
TIS 8164	3.4	2.7	1.9	4.5
Total tuber yield (t/ha)				
TIS 87/0087	5.2	12.7	9.4	9.7
TIS 8164	4.5	3.1	2.3	7.5
	Weight of marketable (t/ha)			Total tuber yield (t/ha)
$LSD_{0.05}$	3.8			3.93

Table 6: Yield and yield components of two sweet potato varieties as influences by time of K application in 2006 cropping season

	No. of unmarketable tubers/m^2	No. of marketable tubers/m^2	Total no. of tubers/m^2	Marketable tuber yield (t/ha)	Total tuber yield (t/ha)
Sweet potato varieties					
TIS 87/0087	3.0	4.0	7.0	21.6	25.7
TIS 8164	2.6	3.1	5.7	12.9	17.1
$LSD_{0.05}$	ns	0.7	1.1	3.9	4.8
Time of K application					
No application	2.0	1.2	3.4	5.4	7.9
100 kg K/ha at 2 WAP	2.0	1.8	3.8	11.4	13.4
100 kg K/ha at 4 WAP	3.6	3.8	7.3	19.7	22.9
100 kg K/ha at 6 WAP	3.3	4.0	7.4	17.9	21.3
100 kg K/ha at 8 WAP	3.4	4.0	7.4	18.8	22.6
50 kg K/ha at 2 WAP + 50 kg K/ha at 6 WAP	2.5	4.5	7.0	25.9	30.0
50 kg K/ha at 2 WAP + 50 kg K/ha at 8 WAP	2.4	5.1	7.5	21.9	24.7
50 kg K/ha at 4 WAP + 50 kg K/ha at 8 WAP	3.3	4.1	7.5	17.2	28.2
$LSD_{0.05}$	1.6	1.5	2.2	7.7	9.6

DISCUSSION

The choice of variety and a good fertilizer management programme are important options for ensuring good crop growth and yield (Opara and Asiegbu, 1994: Okpara *et al*., 2004). TIS 87/0087 sweet potato variety performed better than TIS 8164 probably because of higher leaf, vine, tuber and total dry weights of TIS 87/0087 than those of TIS 9164. Also, the marketable and total number of tubers/m^2 as well as the tuber yield and yield components of TIS 87/0087 variety were higher than those of TIS 8164 at all modes of K application. In 2005 cropping season, the number of marketable tubers/ was higher in TIS 87/0087 than TIS 8164 by 189, 231 or 42% when 100 kg K/ha was applied at 4, 8 WAP or split application of K at 4 + 8 WAP, respectively. The corresponding values for total number of tubers/ m^2 were 256.5, 62 or 71%, respectively. The total tuber yields/ha were higher for TIS 87/0087 by 310, 309 0r 86.5% than TIS 8164 with the application of the whole K at 4, 8 WAP or split at 4 + 8 WAP, respectively. In 2006, irrespective of the mode of K application, TIS 87/0087 variety also performed much better than TIS 8164. The better performance of TIS 87/0087 over TIS 8164 might be due to its better genetic constitution and more vigorous growth (Njoku, 2000). While TIS 87/0087 has trailing habit with its leaves well displayed for photosynthesis and dry matter production, TIS 8164 variety has bunchy habit with most of its leaves being shaded (Larbi *et al*., 1997). The high yields of TIS 87/0087, which were triple those of TIS 8164 indicated high efficiency and more promising variety. The high total dry matter for TIS 87/0087 could be due to its bulking efficiency and vigorous growth habit. Okwuowulu and Asiegbu (2000), Njoku (2000) and Njoku *et al*. (2007) also reported the superior performance of TIS 87/0087 compared to other sweet potato varieties.

The need to make soils more productive and sustainable has necessitated judicious use of fertilizers. Advice given to farmers on fertilizer usage has always been based on rates but rarely on time of application, especially with regard to K. The present study was aimed at finding out the mode of application and the best time for this application. It assumed that sweet potato varieties respond to time of K application. In the work reported here, the sweet potato varieties used yielded higher with split application compared single whole application, especially when K was split applied at 2 + 6 WAP or 4 + 8 WAP. The better performance of the varieties with split K application could be due to nutrient availability all through the crop growth duration and during tuber bulking. Increasing availability of K had been reported to accelerate the translocation of photosynthates to the tuberous sink with consequent increase in root tuber yield (Hahn, 1977; Obigbesan, 1980; Tsuno, 1981). Other workers had reported better performance of split fertilizer application over single application in other crops such as tomato (Fawusi, 1977; Amans *et al*., 1996; Oko and Asiegbu, 2001), sugarcane (Ng Kee Kwang and Deville, 1989), rice (Gobi *et al*., 2006). However, there is controversy with regard to the number of splits to be adopted and the best time to apply the splits (Oko and Asiegbu, 2001). Singh and Singh (1974) were of the view that the number of splits to be adopted depends on the nature of the soil to be of nutrient loss.

In southern Nigeria with its attendant high rainfall and high rates of nutrient loss by leaching during the rainy season, 2 or 3 split applications of fertilizer, especially mobile N and K would ensure optimal availability at specific physiological stage of crops and therefore improve yield (Fawusi, 1977). Gobi *et al*. (2006) suggested up to four splits of N and K for rice in India.

The soil of Umudike, Nigeria (the experimental site) has low cation exchange capacity (CEC) and, therefore, has limited capacity to retain the major plant nutrient cations such as Ca, Mg and K. This low CEC coupled with high rainfall usually encountered in the area causes extensive leaching of K and other nutrient cations. This necessitates split application, one at the early growth stage and the others towards the onset of reproductive phase to ensure accumulation of economic yield of the crop.

CONCLUSION

The TIS 87/0087 which is a higher yielding variety is recommended for the study area with split application of K at 2 WAP + 6 WAP or at 4 WAP + 8 WAP. It produced higher marketable and total tuber yields.

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