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GROWTH AND YIELD RESPONSES OF SWEET POTATO TO INORGANIC NITROGEN AND POTASSIUM IN A TROPICAL ULTISOL

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ABSTRACT

A 4 x 4 factorial experiment in a randomized complete block design with three replications was used to study the responses of sweet potato to nitrogen and potassium fertilizer application in a tropical ultisol at Umudike in 1998 and 1999 cropping seasons. Treatments comprised four nitrogen levels of 0, 40, 80 and 120kgN/ha and four potassium levels of 0, 50, 100 and 150kgK/ha.

Nitrogen fertilizer significantly increased shoot dry matter yield. Mean tuber yield was significantly increased with application of nitrogen up to 40kgN/ha. Potassium fertilizer application depressed shoot dry matter but significantly increased marketable and total tuber yields. For optimum marketable tuber yields, nitrogen at 40kgN/ha combined with potassium at 150kgK/ha would be recommended.

INTRODUCTION

Sweet potato (Ipomea batatas (L) Lam) ranks fifth in the list of the most valuable food crops of developing countries (Woofe, 1992). Within sub-saharan Africa, it is regarded as the third most important root and tuber crop after cassava and yam (Hahn and Hozyo, 1998). Sweet potato tubers provide starchy food staple containing vitamins, particularly vitamin A and minerals comparable to those of various fruits (Truong, 1989) while its leaves contain about 34.5 percent crude protein (Nwinyi, 1988).

Sweet. potato is annually cultivated on 0.2 – 0.3 million hectares of Nigeria's land area (Yayock, 1980). It is a minor crop that was neglected in the past, but which is now assuming increasing importance as a source of food in the country. Although, yields are still low in many countries, including Nigeria, it has been shown that there is tremendous potential for increasing yield by the introduction of improved varieties and more efficient cultivation practices. Nutrient deficiency has been shown to significantly account for low yields in the traditional farming system due to short or no bush fallow periods (FAO, 1975).

In sweet potato cultural management, potassium application has been identified as a factor affecting tuber bulking and yield. The application of high potassium and nitrogen rates boosts sweet potato production (Hahn and Hozyo, 1984). CIP (1980) reported that potassium application reduces excessive vegetative growth following high nitrogen application. There is, however, lack of research information on the optimum rates of nitrogen and potassium fertilizers requirements of some newly bred varieties of sweet potato under the humid tropical conditions of southeastern Nigeria.

The objective of the present study was, therefore, to determine the optimum rates of nitrogen and potassium fertilizers for the TIS 87/0087 variety of sweet potato under the agroecological conditions of southeastern Nigeria at Umudike.

MATERIALS AND METHODS

Two field experiments were conducted in 1998 and 1999 cropping seasons at the National Root Crops Research Institute.

(NRCRI), Umudike, farm under rainfed conditions. The location is situated at longitude 07° 34^{1}E, latitude 05°29^{1}N and at an elevation of 122m above sea level.. The soil is a sandy clay loam classified as an Ultisol. Some of the soil characteristics and rainfall data are summarized in Table 1.

Lands which were previously under cassava but under a two year fallow at the time the experiments started were disc ploughed on 12th July, harrowed on 16th July, ridged 1m apart and sampled for analysis on 20th July in 1998 and 1999. The experiments comprised four levels of nitrogen (0,50,100 and 150kgK/ha), in a randomized complete block factorial design with three replications. Plots measured 6m x 4.5m (27m^2) each.

Sweet potato variety TIS87/0087 vine cuttings of 20cm length were planted 30cm apart along the crest of ridges on July 22 in 1998 and 1999. The plants were spaced at 1m x 0.3m to maintain a plant population of 33,333 plants/ha. Supply of vacant stands was done 2 weeks after planting (WAP). Nitrogen as urea and potassium as muriate of potash were applied 6 WAP on the appropriate plots. Each plot also received a blanket application of 25KgP_2O_5/ha as single super phosphate at the same time as the nitrogen and potassium fertilizers were applied. Hoe weeding was done once at 4WAP.

Records were taken on dry weight of shoot (g/plant), number of tubers/m^2, tuber weight (g/plant) and tuber yield (t/ha). The tubers were harvested at 16 WAP and grades based on weight as follows: Marketable tuber > 100g, unmarketable tubers < 100g. Statistical analysis of data was done according to the procedures outlined for randomized complete block design and means were separated using the least significant difference at P=0.05 (Gomez and Gomez, 1984).

RESULTS

The soil data showed the experimental sites to be texturally a sandy clay loam (Table 1). The soils were marginal in nitrogen and organic matter contents, moderately high in potassium and phosphorus contents. The total rainfalls for the experimental period of July to November in 1998 and 1999 we e 1107.4mm and

Table 1: Soil Properties of the Sites and Monthly Rainfall for the Experimental Periods in 1998 and 1999.

	1998	1999
Mechanical properties of soil		
Sand (%)	67.0	64.8
Clay (%)	28.0	30.8
Silt (%)	5.0	4.4
Textural class	Sandy clay loam	Sandy clay loam
Chemical properties of soil		
Total N (%)	0.18	0.16
Total P (ppm)	25.0	24.0
O. M. (%)	3.48	3.22
Exchangeable cations (Meq/100 soil		
Ca	1.83	1.66
K	0.46	0.38
Mg	1.54	1.28
Na	0.08	0.08
Monthly rainfall (mm)		
July	**243.2**	**284.4**
August	**310.7**	**382.2**
September	**287.6**	**395.3**
October	**195.8**	**433.7**
November	**70.1**	**50.1**
Total for period	**1107.4**	**1545.7**

1545.7mm, respectively.

On average, incremental application of nitrogen up to 80kgN/ha and 120kgN/ha significantly increased shoot dry matter in seed potato at 14WAP in 1998 and 1999, respectively (Table 2).

Compared with where potassium was not applied, all cases of applied potassium depressed shoot dry matter yield. The greatest dry matter yield were produced with a combination of 80kgN/ha and 150kgK/ha in 1998 and 120kgN/ha without potassium in 1999.

Nitrogen application did not significantly affect the number of marketable tubers (Table 3)

However, total number of tubers/m^2 was increased at 40kgN/ha compared with other nitrogen rates in 1999. Compared with no potassium application, the number of tu

ber/m^2 was increased with application of potassium at 150kgK/ha in 1998 and in all cases of applied potassium in 1999. The greatest number of tubers/m^2 was mostly produced at 150kgK/ha, irrespective of nitrogen levels.

On average, application of 40kgN/ha increased the yield of marketable tubers over where no nitrogen was applied (Table 4)

Table 2: Effect of Nitrogen and Potassium on Shoot Dry Matter (g/plant) of Sweet Potato in 1998 and 1999.

		Nitrogen (KgN/ha				
	Potassium (KgK/ha)	0	40	80	120	Mean
1998	0	322.5	340.7	573.1	381.0	404.3
	50	166.8	271.7	316.5	636.1	347.8
	100	175.1	244.5	361.8	298.0	269.9
	150	212.8	271.8	645.3	349.8	369.9
	Mean	219.3	282.2	474.2	416.2	
1999	0	184.1	225.6	247.4	362.6	254.9
	50	198.6	180.5	276.1	250.8	226.5
	100	114.6	200.0	265.0	222.1	200.4
	150	130.8	186.5	178.5	359.4	213.9
	Mean	157.0	198.1	241.8	298.7	
		1998	1999			
LSD (P=0.05) for 2 mitrogen (N) means		41.7	21.6			
LSD (P=0.05) for 2 potassium (K) means		41.7	21.6			

LSD (P=0.05) for N x K means 83.4 43.3 Nitrogen (KgN/ha) Nitrogen (KgN/ha)

Table 3: Effect of nitrogen and potassium on number of tubers/m² in sweet potato

	Nitrogen (kgK/ha)				
Potassium (kgK/ha)	0	40	80	120	Mean
Number of marketable tubers/m²	1998				
0	3.7	4.3	3.3	4.3	3.9
50	3.7	5.1	4.6	4.6	4.5
100	4.9	4.1	4.5	4.9	4.6
150	5.1	4.5	5.5	5.5	5.2
Mean	4.4	4.5	4.5	4.8	
		1999			
0	3.3	3.7	3.1	3.5	3.4
50	3.8	4.9	4.0	4.1	4.2
100	4.4	4.7	4.6	4.0	4.4
150	4.1	5.1	5.1	5.4	4.9
Mean	3.9	4.5	4.2	4.3	

Table 3 Continued:

Total number of tubers/	1998				
0	6.0	7.2	5.7	6.0	6.2
50	6.4	7.8	6.4	6.3	6.7
100	7.8	6.9	6.5	6.5	6.9
150	7.4	6.9	7.8	7.4	7.3
Mean	6.9	7.2	6.6	6.6	
	1999				
0	6.5	6.7	6.0	5.8	6.3
50	6.9	8.0	6.4	6.2	6.9
100	6.6	7.9	7.3	6.7	7.1
150	7.8	8.0	7.9	7.9	7.9
Mean	6.9	7.7	6.9	6.6	

	Marketable Total			
	1998	1999	1998	1999
L S D (P=0.05) for 2 nitrogen (N) means	0.8	0.8	1.0	0.8
L S D (P=0.05) for 2 potassium (K) means	0.8	0.8	1.0	0.8
L S D (P=0.05) for N x K means	1.6	1.6	1.8	1.6

Increasing nitrogen application to 80 or 120kgN/ha did not result in any reasonable yield benefits over where 40kgN/ha was applied. The yield of marketable tubers increased with potassium application, such that application of 50 or 100kgK/ha increased tuber yield compared to where potassium was not applied while application of 150kgK/ha increased it over where 50kgK/ha or 100kgK/ha was applied. The highest yield of marketable tubers, as average of both years, was obtained where nitrogen was applied at 40kgN and potassium applied at 150kgK/ha. No remarkable yield increments were obtained with combined application of 80 or 120kg/ha nitrogen and 150/ha of potassium over where 40kgN/ha was applied with 150kgK/ha. Total yield of sweet potato tubers largely followed similar trends as yield of marketable tubers.

DISCUSSION

The findings showed that shoot dry matter yield in sweet potato was increased by applying nitrogen up to 80kgN/ha. Potassium application, however, suppressed the accumulation of dry matter in the shoot. Tsuno and Fujise (1964) had reported that nitrogen increased dry matter production of sweet potato by increasing leaf expansion. This result supports the view of Stino (1953) who, while working in Eqypt, concluded that sweet potato vine growth was increased as a result of nitrogen application but not with application of potassium. Duncas et al (1988) had also reported that sweet potato dry matter content decreased with increased potash fertilization.

The yield increases obtained with nitrogen and potassium applications were due mainly to increases in the number of tubers/m^2. However, application of nitrogen is usually credited with the building up of leaf tissues while potassium is essential for increased photosynthetic activity (Forbes and Watson, 1994; Hahn, 1984; Tsuno and Fujise, 1964), factors which are important for crop performance.

The fertilizer rates of 40kgN/ha and 150kgK/ha appeared adequate for obtaining optimum tuber yields in sweet potato, on average. Application of more than 40kgN did not significantly benefit tuber yields further and would not be recommended. The average total yield of 21.6t/ha obtained in this study, for the TIS 87/0087 variety using

40kgN and 150kgK/ha was comparatively higher than the 11.3t/ha total yield which Nwinyi (1988) obtained in a similar environment for sweet potato cultivar, Dukupuku, using fertilizer recommendation of 70kgN and 140kgK/ha. FAO (1962) recommended the application of 60kgN and 120kgK_2O/ha for sweet potato grown in Japan. Evidently, the disparity in yield as well as nitrogen and potassium needs could be accounted for by a number of factors, including the original status of the soil with respect to the nutrient elements, other edaphic factors, varietal differences and climatological variations that occur from year to year and with locations.

Large-sized tubers attract higher prices and the results showed that the proportions of marketable tubers in the overall tuber yield were greatly increased when nitrogen was applied at 40kgN/ha and potassium applied at 150kgK/ha compared with where no nitrogen was applied and lower potassium rates, on average. The response to potassium application aggress with the observations of Hahn and Hozyo (1984), which indicated that very high doses of potassium were essential for tuber production and bulking in sweet potato.

On average, tuber yields were over 32 percent higher in 1998 compared with 1999. The higher rainfall of 1999 contributed to the yield disparity by lowering yields of that year. Nwinyi (1988) made a similar observation. Lack of oxygen and excess moisture in the soil have adverse effects on fleshly root formation and enlargement, with the result that less tuberous root and tôtal dry matter per unit area of lamina were produced in a wet regime (Spence and Humphrey, 1972).

CONCLUSION

Based on the conditions of this investigation, it is concluded that fertilizer use in sweet potato would be optimized by the application of 40kgN/ha and 150kgK/ha at Umudike in Southeastern Nigeria.

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