Nitrogen and Potassium Responses of Two Cassava Varieties Grown on an Alfisol in Southern Nigeria

Authors: B.T. Kang and J.E. Okeke, International Institute of Tropical Agriculture, Ibadan, Nigeria, and Root and Tuber Crops Research Institute, Umudike, Nigeria, respectively.

ABSTRACT

A fertilizer trial on an Alagba soil series (Oxic Paleustalf) at Ikenne in the forest zone of southwestern Nigeria for three consecutive croppings to determine responses of cassava varieties TMS 30555 and TMS 30572 to N and K.

Nitrogen application increased plant top yield and N percentage in leaves with no significant effect on tuber yield. Potassium application significantly increased plant top yield, leaf K percentage and tuber yield. Potassium response was observed in the second year of continuous cassava cropping with variety TMS 30555 and in the third year with variety TMS 30572. Variety TMS 30572 appears to be more effective in utilizing soil K. Potassium response can be expected on this Alagba soil series when IN Am. Acetate extractable soil K test level is ≤ 0.15 me/100g soil. The cassava crop also responded to K application when the K level of the index leaf blade is ≤ 0.1% K.

Introduction

Cassava is widely grown in the humid region of West Africa on diverse soil types. A relatively large acreage is grown on Alfisols derived from sedimentary parent materials. These soils are known to have low nutrient status and particularly low potassium reserve (Juo and Grimme, 1980). Potassium deficiency usually develops in these soils 3 to 4 years following land clearing from secondary bush fallow with intensive cropping (Kang, 1980). In the traditional bush fallow system cassava is usually planted as the last crop during the cropping cycle and yields are often low - in the order of 6 to 8 tons/ha. This low yield is in part attributable to low soil nutrient status resulting from depletion by preceeding crops.

To meet the increasing demand for this staple food, various agencies in the area attempt to boost cassava production. Investigations to determine the N, P and K responses particularly of high yielding varieties (Amon and Adetunji, 1973; Ofori, 1973; Takyi, 1974; Obigbesan and Fayemi, 1976; Obigbesan, 1977, Kang et al., 1980) show that N and K responses are more common than response to P. Results of fertilizer trials in southwestern Nigeria between 1960-1965 also showed that K response was common on the acid sandy Ultisols (J.E. Okeke, unpublished report). However, with increasing interest for establishing large commercial production units in the region, data on the nutrient requirement for continuous production is not available. To meet this need, several long term fertilizer management studies were undertaken in southern Nigeria. This paper reports results of N and K fertilizer trials on an Alfisol for three cropping seasons.

Materials and Methods

The field trial was at Ikenne (6°50'N and 3°41'E) in the forest zone of southwestern Nigeria from 1978 to 1981. Following land clearing from secondary regrowth, the experimental site was cropped once with upland rice prior to the experiment. The soil, an Alagba soil series, is a clayey, kaolinitic, isohyperthermic member of the Oxic Paleustalf, derived from sandy sedimentary materials. The surface soil has a sandy loam texture and the following chemical properties at the start of the experiment: pH (in 1:1 soil:water ratio), 5.9; organic C, 1.30%, total N, 0.17%, ECEC, 4.23 me/100g; 1N NH_4-acetate extractable Ca, Mg and K of 2.57, 1.40 and 0.23 me/100g respectively; extractable Bray P-1, 8.9 ppm P.

The experiment used a split plot design with four replications. Two cassava varieties, TMS 30555 and TMS 30572, were the main plot treatments. Six sub-plot treatments consisted of a control and combinations of three levels each of N and K fertilizer treatments (see Table 1). Nitrogen (calcium ammonium nitrate), half applied at 4 weeks after planting (WAP) and the remainder at 4 months after planting (MAP). Potassium (muriate of potash) was applied at planting. Phosphorus (single superphosphate) was also applied to all treatments at the rate of 30 kg P/ha per crop. Cassava was planted at 1x1 m spacing. Harvested plot size was 30 m^2. At harvest tuber subsamples were taken and dried at 65°C to estimate dry tuber yields.

To determine plant nutrient status, leaf blade samples were collected from the first mature leaves at about 4 MAP. After drying and grinding in stainless steel mill, the plant samples were wet digested and analysed for P, K, Ca, Mg, Mn and Zn contents. Nitrogen was determined from a separate subsample using the micro Kjedahl method.

Results and Discussion

Growth and Yield

Variety TMS 30572 showed better growth than variety TMS 30555. Distinct differences in growth due to fertilizer treatments were only observed in the third crop. Plants from the no fertilizer and no N treatments were slightly chlorotic. Plants from the no K treatments were also chlorotic with shorter plants and smaller leaves. Severe bacterial blight infestation was obvious with both varieties in the no K treatment. Odurukwe and Arene (1980) also reported reduction in severity of bacterial blight infestation with K application.

Yield of the 1978-1979 crop is not presented. Due to too early harvesting at 11 MAP, tuber yield was low, below 5 tons fresh tuber/ha. There was no significant differences in tuber yield between the various treatments. The plants from the control and no N treatments showed higher tuber yield than those receiving N. In thus appears that N application delayed tuber bulking, a similar observation was also reported by Kang and Wilson (1980).

Table 1. Effect of nitrogen and potassium application on fresh tuber yield of cassava varieties TMS 30555 and TMS 30572 grown on Alfisol (Oxic paleustalf) at Ikenne.

Fertilizer N	Treatment K	1980			1981		
		TMS 30555	TMS 30572	Mean	TMS 30555	TMS 30572	Mean
(kg/ha)		(tons/ha)					
0	0	19.5	19.5	19.5	17.6	15.1	16.4
0	120	21.5	21.1	21.2	23.3	19.6	21.5
60	120	23.3	25.4	24.4	18.2	17.3	17.8
120	120	21.4	21.8	21.6	19.4	19.8	19.6
120	0	18.3	21.9	20.1	13.5	13.9	13.7
120	60	21.6	23.1	22.4	20.9	21.7	21.3
Mean		20.9	22.1		18.8	17.9	
LSD .05	(I)	3.1			1.5		
	(II)	3.1			3.6		
	(III)	4.1			5.1		
	(IV)	4.4			4.9		

(I) Between variety means.
(II) Between fertilizer treatment means.
(III) Between fertilizer treatments within variety.
(IV) Between fertilizer treatments among varieties.

Tuber yields from the 1980 and 1981 harvests are in Table 1. Harvested at 13 MAP, relatively high fresh tuber yields were obtained above 18 tons/ha with K application. The yield in 1981 was slightly lower. There were no significant differences in fresh tuber yield between the two varieties. In 1980 the control treatment showed slightly lower yield than the fertilized treatments. Highest yield was observed with combined application of 60 kg N/ha and 120 kg K/ha. Variety TMS 30555 showed a significant response to K application in this year.

The 1981 yield showed the same trend as that observed in 1980. Yield of the control was significantly lower than from the combined N and K treatments. In contrast to the 1980 result where application of 60 kg N/ha increased yield, in 1981 N application depressed yield particularly of variety TMS 30555. This yield depression is probably related to the higher degree of bacterial blight infestation in this variety with N application. A significant response to application of 60 kg K/ha was observed with both varieties in this year.

The dry tuber yield from the 1981 harvest is in Table 2. Dry tuber yield showed the same trend as of fresh tuber yield. The dry tuber percentage of variety TMS 30555 was slightly higher (38.1%) than that of variety TMS 30572 (36.1%). The lowest percentage was observed with variety TMS 30572 with no K application (32.8%).

Table 3 shows the plant top yield from the 1980 harvest. Variety TMS 30572 was significantly higher in plant top yield than variety TMS 30555. Plant yield also increased significantly with N and K applications, with variety TMS 30572 showing higher yield response.

Table 2. Effect of nitrogen and potassium application on dry tuber yield on cassava varieties TMS 30555 and TMS 30572 grown on Alfisol (Oxic paleustalf) at Ikenne in 1981.

Fertilizer N	Treatment K	Variety TMS 30555	Variety TMS 30572	Mean
(kg/ha)		(tons/ha)		
0	0	6.7	5.4	6.1
0	120	9.0	6.5	7.8
60	120	6.8	6.4	6.6
120	120	7.2	7.1	7.2
120	0	5.1	4.6	4.9
120	60	8.2	8.0	8.1
Mean		7.2	6.3	
LSD .05 (I)		1.1		
(II)		1.7		
(III)		2.4		
(IV)		2.4		

(I) Between variety means.
(II) Between fertilizer treatment means.
(III) Between fertilizer treatments within variety.
(IV) Between fertilizer treatments among varieties.

Table 3. Effect of nitrogen and potassium application of fresh top yield of cassava varieties TMS 30555 and TMS 30572 grown on Alfisol (Oxic paleustalf) at Ikenne, harvested in 1980.

Fertilizer N	Treatment K	Variety TMS 30555	Variety TMS 30572	Mean
(kg/ha)		(tons/ha)		
0	0	19.0	25.9	22.5
0	120	22.6	26.1	24.4
60	120	24.6	31.0	27.8
120	120	29.5	36.2	32.9
120	0	19.6	28.1	23.9
120	60	24.8	33.4	29.1
Mean		23.4	30.1	
LSD .05 (I)		4.3		
(II)		5.8		
(III)		8.1		
(IV)		8.5		

(I) Between variety means.
(II) Between fertilizer treatment means.
(III) Between fertilizer treatments within variety.
(IV) Between fertilizer treatments among varieties.

There appears to be little relationship between plant top yield (Table 3) and tuber yield (Table 1) with N application. The increased top yield with N application had little effect on tuber yield. However, application of K significantly increased top and tuber yields. The plant top yield of variety TMS 30555 was more affected by K application than that of variety TMS 30572.

Soil Potassium Status

The soil potassium status showed a sharp decline from its original value of 0.23 me at the initiation of the experiment with continuous cassava cropping. As in Table 4, the decline was more pronounced in the no K than in the control treatment. Considering the surface soil K data sampled at 1 MAP in relation to the fresh tuber yield for the 1979-1980 and 1980-1981 croppings, it appears that K response can be expected on this soil type when the IN Am. Acetate extractable soil K test value is below 0.15 me. Obigbesan (1977) also observed K response on tuber yield in similar soil with test value of 0.12 me K. However, no K response was observed on soils derived from basement complex rocks which have soil K test values ranging from 0.15 to 0.08 me, probably due to the higher K reserve in these soils.

Table 4. Extractable (IN ammonium acetate) potassium levels in surface soil of Oxic paleustalf at Ikenne as affected by nitrogen and potassium applications.

Fertilizer N	Treatment K	Year 1979*	1980*	1981**
(kg/ha)			(me/100g)	
0	0	0.15	0.12	0.10
0	120	0.21	0.17	0.12
60	120	0.21	0.18	0.11
120	120	0.18	0.16	0.11
120	0	0.12	0.09	0.09
120	60	0.17	0.13	0.11

*Sampled one month after planting.

**Sampled at harvest.

Plant Nutrient Status

The nutrient status of the index leaves from the 1980-1981 cropping is in Table 5. Little differences is noted in the mean N status between the two varieties. However, variety TMS 30572 showed higher K percentage. There was a pronounced increase in N percentage with N application. Decreasing N status with increasing K application was probably due to a dilution effect, since K application increased top growth (Table 3). It is interesting to note that the N percentage was near or below the critical value of 4.5% N given by Asher et al. (1980). Yet, there was no significant effect of N application on tuber yield of variety TMS 30572, and even negative effects on tuber yield of variety TMS 30572 and on tuber yield of variety TMS 30555 (Table 1). The K leaf status with no K application was near to the critical value of 1% K given by Asher et al., (1980). There appears to be little difference in the leaf P, Ca, Mg, Mn and Zn percentages between the two varieties. Nitrogen and K applications also have no significant effect on the status of the other nutrients.

Table 5. Nutrient composition of cassava index leaves as affected by nitrogen and potassium application.

Treatment N (kg/ha)	Treatment K (kg/ha)	N	P	K (%)	Ca	Mg	Mn (ppm)	Zn (ppm)
				Variety 30555				
0	0	4.43	0.37	1.17	1.45	0.76	176	30
0	120	3.60	0.35	1.26	1.38	0.75	176	34
60	120	4.03	0.37	1.39	1.38	0.67	168	34
120	120	4.14	0.37	1.42	1.62	0.72	195	41
120	0	4.94	0.36	0.99	1.55	0.80	157	39
120	60	4.77	0.37	1.32	1.44	0.71	153	33
Mean		4.32	0.37	1.26	1.47	0.73	170	35
				Variety 30572				
0	0	4.13	0.37	1.37	1.38	0.67	195	41
0	120	3.73	0.35	1.50	1.35	0.61	202	38
60	120	4.01	0.38	1.61	1.45	0.72	228	41
120	120	4.28	0.38	1.55	1.39	0.65	206	41
120	0	4.85	0.36	0.15	1.34	0.69	191	34
120	60	4.83	0.38	1.32	1.52	1.67	191	41
Mean		4.30	0.37	1.42	1.40	0.66	202	39
LSD .05	(I)	0.17	0.02	0.21	0.22	0.06	18	6
	(II)	0.47	0.03	0.29	0.27	0.10	38	11

(I) Between variety means.
(II) Between fertilizer treatments among varieties.

Results of the present trial showed the importance of K application for continuous cassava production on this Alfisol derived from sandy sedimentary materials. Even with three consecutive cassava croppings, N application only affected plant top yield (Table 3) and leaf N status (Table 5), but had no significant effect on tuber yield. It is to be expected that with subsequent croppings N application will be needed. However, in this soil with low K reserve (Juo and Grimme, 1980), K response was already obtained in the second cassava cropping with variety TMS 30555 (Table 1). Variety TMS 30572, which has a more robust growth, appears to be more effective in utilizing soil K and only showed K response in the third cropping year. A maintenance dressing of K at the rate of 60 kg K/ha is thus recommended early in the cropping cycle for continuous cassava production on this soil type. A response of the cassava crop to K application can be expected in this soil when the 1*N* Ammonium acetate extractable K is $\leq$ 0.15 me in the surface soil.

Although some investigators have observed positive correlation between cassava tuber yield and total plant top yield (Ngongi et al., 1976), data presented only support such relationship with K application but not with N application.

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