Potassium Nutrition and Translocation in Cassava (*Manihot esculenta* Crantz) intercropped with Soybean

Abstract

Experiment to investigate the effect of potassium nutrition and translocation in cassava (*Manihot esculenta* Crantz) intercropped with soybean (*Glycine max* (L) Merril) was conducted at University of Nigeria, Nsukka in a derived savannah location of South Eastern Nigeria. The Effect of application of potassium fertilizer on two varieties of cassava intercropped with six cultivars of soybean was studied. Cassava tuber yield was significantly ($P<0.05$) affected by their varieties, fertilizer rate and cropping system. An increase in the supply of K^+ by fertilization (N_0K_{50} and $N_{45}K_{50}$) increased K^+ accumulation in source leaves and caused increase in cassava tuber yield. The highest cassava tuber yield (42.0 $t.ha^{-1}$) was obtained with the fertilizer rate of N_0K_{50} x NR 8230 intercropped with TGX 1894-3E followed by the yield (40.5 $t.ha^{-1}$) of the same cassava cultivar (NR 8230) x $N_{45}K_{50}$ intercropped with Samsoy-2.

Key words: Cassava, soybean, potassium, nutrition, intercrop, translocation

INTRODUCTION

Potassium is an element essential to plant for the formation and transfer of carbohydrate in photosynthesis and also for protein synthesis. It is particularly important for fruits, leaves and stems and is needed to strengthen the plant's structure. Potassium promotes high crop yields, particularly in root and tuber crops. Potassium helps to direct free nutrients such as carbon, hydrogen and oxygen out of the atmosphere and into the plant. Various studies provide evidence that K^+ nutrition promotes the translocation of assimilates in plants. Without the activity of potassium, photosynthesis would be severely restricted and plant would struggle to make starches, sugars, proteins, vitamins, enzymes and cellulose. Net carbon exchange in plant increases as a result of increased K^+ fertilization (Amir and Reinhold, 1971). Potassium aids in helping the plant through adverse climate in that, when potassium is out of balance, plant stress is very high (Umeh and Mbah, 2010a). When too much potassium is used, synergistic reaction occurs between calcium and magnesium, thereby changing the soil pH rapidly. At high pH, up to pH 6, potassium mobility slows down, and as soil reaches 7.0, mobility is severely hindered. Potassium reserve in soil is largely dependent on the type of soil mineral present in the soil. Soil potassium may be classified according to its availability to plants and falls into three categories: the inert reserve or slowly available K, the dynamic reserve and the readily available reserve (Defoer *et al.,* 2000). The ratio of potassium exported through crop removal: exchangeable K indicates how long a farmer can afford to continue to extract K without adding potassium fertilizer.

Brennan and Jayasena (2007) reported that increasing applications of potassium fertilizer to barley crops grown on deficient sandy soils increased grain yield and decreased some foliar diseases. At the international Potash Institute (IPI), Srinivasarao *et al.* (2007) categorised soils based on potassium reserve and production systems. They observed positive correlations with exchangeable and non-exchangeable K in all soil types indicating the

dynamic equilibrium between the two soil- K^+ fractions. Increasing the K^+ available to the roots of cassava caused an increase to the delivery of K^+ to the leaves of the plant and possible increase in the cassava tuber yield (Kang and Okeke, 1983). Haeder and Mengel (1972) found that increasing K^+ supplies to the roots caused increased translocation of carbon in tomato fruits. Earlier studies (Kang and Okeke, 1983) examined the responses of cassava varieties to N and K. This study was conducted to investigate the effect of potassium nutrition and translocation in cassava intercropped with soybean.

MATERIALS AND METHODS

The experiment was conducted at University of Nigeria, Nsukka farm which is located at latitude 06^0 52''N and longitude 07^0 24''E and at 447m above the sea level, between August 2008 and July 2009. Experimental design was split plot in randomised complete block design, having two factors; fertilizer rates and cropping systems. Six varieties of soybean of three maturity classes (early, medium and late maturing) were intercropped with two varieties of cassava. Four fertilizer rates were randomised in the main plots, while twenty cropping systems comprising six sole soybean, two sole cassava and twelve cassava/soybean intercrop were randomised in the sub- plots.

Cassava varieties used were TMS 30572 and NR 8230. The six varieties of soybean used were TGX 1448-2E and Samsoy-2, (early maturing varieties), TGX 1894-3E and TGX 1805-31F,(medium maturing varieties),`TGX 1889-12F and TGX 1864-17F, (late maturing varieties). The four fertilizer rates were: N_0K_0, N_0K_{50}, $N_{45}K_0$ and $N_{45}K_{50}$ kg. ha^{-1}, where N and K were nitrogen and potassium respectively, subscripts 0, 45 and 50 were levels of N and K $kg.ha^{-1}$ respectively. The nitrogen source was Urea and potassium source was muriate of potash. A uniform application of 30 $kg.ha^{-1}$ of P as single supper phosphate was applied to all plots.

Plot size was 4.0 m X 3.0 m., containing 4 ridges at 1.0 m spacing. Soybean was planted on both sides of the ridge at a plant distance of 10.0 cm while cassava was planted at a plant distance of 0.75 m. on the crest of the ridges. Both cassava cuttings (20 cm long) and soybean seeds were planted at the same time. Cassava plant population was 13,333.33 plants ha^{-1} while soybean was thinned down to plant population of 200,000 plants ha^{-1}. Planting was done in early August and weed was controlled manually. Cassava tuber yield, shoot dry matter and potassium content were determined at 12 months after planting. Uptake of K was determined as accumulation of K in cassava leaf and cassava tuber using atomic absorption spectrophotometric method.

Key: N_0K_0 = 0kg N ha^{-1} and 0kg K ha^{-1}: N_0K_{50} = 0kg N ha^{-1} and 50kg K ha^{-1}:
$N_{45}K_0$ = 45kg N ha^{-1} and 0kg K ha^{-1} :$N_{45}K_{50}$ = 45kg N ha^{-1} and 50kg K ha^{-1}

RESULTS

Effect of potassium rate and cropping system on cassava tuber yield ($t.ha^{-1}$) at 12 MAP was presented in table 1. Application of N_0K_{50} fertilizer rate out-yielded all other fertilizer rates (30.7 $t.ha^{-1}$), which was 204% higher than the yield at N_0K_0 (12.6 $t.ha^{-1}$), 108% higher than at $N_{45}K_0$, (28.4 $t.ha^{-1}$) and at $N_{45}K_{50}$ (28.0 $t.ha^{-1}$). The tuber yield at $N_{45}K_0$ and $N_{45}K_{50}$ did not differ significantly. There were no significant yield differences between the two cassava cultivars as sole crop. However, at intercrop, NR 8230 intercropped with TGX 1894-3E produced significantly ($P < 0.05$) the highest tuber yield (30.8 $t.ha^{-1}$) which was 57% higher than the sole crop (19.03 $t.ha^{-1}$).

All intercrop cassava significantly ($P < 0.05$) out yielded sole cassava except NR 8230 intercropped with TGX 1448-2E (17.9 t. ha^{-1}) which significantly yielded lower than both cassava sole crops (19.0 and 18.6 $t.ha^{-1}$ respectively). Generally, NR 8230 significantly out

yielded TMS 30572 when intercropped with all varieties of soybean except with TGX 1448-2E, where the yield of TMS 30572 was 65.8% higher than NR 8230.

The interaction of sole cassava x all fertilizer rates had generally lower tuber yields than when intercropped except at $N_{45}K_0$ and $N_{45}K_{50}$ x NR 8230 intercropped with TGX 1448-2E, $N_{45}k_{50}$ x TMS 30572 intercropped with Samsoy-2 and TMS 30572 intercropped with TGX 1894-3E. The fertilizer rate of N_0K_{50} x NR 8230 intercropped with TGX 1894-3E gave significantly ($P < 0.05$) the highest cassava yield of 42.0 $t.ha^{-1}$ followed by the yield (40.5 $t.ha^{-1}$) of the same cassava cultivar (NR 8230) x $N_{45}K_{50}$ intercropped with Samsoy-2. Medium maturing varieties, TGX 1894-3E and TGX 1805-31F, intercropped with the two cassava varieties gave a more close consistent tuber yield at N_0K_{50} (42.0, 38.9, 38.2 and 38.7 $t.ha^{-1}$) which were significantly ($P < 0.05$) higher than all other soybean varieties x fertilizer rates both at sole and at intercrop. Cassava tuber yield was lowest at sole NR 8230 (4.2 $t.\ ha^{-1}$).

Effects of potassium rate and cropping system on cassava leaf-K at 12 MAP were presented in table 2. Cassava leaf-K differed significantly ($P < 0.05$) with potassium rates. Fertilizer rates of N_0K_{50}, $N_{45}K_0$ and $N_{45}K_{50}$ were 30.26, 11.69 and 29.21% higher than N_0K_0 respectively. Leaf-K at N_0K_{50} (2.71%) was significantly higher than other fertilizer rates, while leaf-K at N_0K_0 (1.89%) was the lowest.

Sole crops did not differ significantly among themselves. Intercrops of TGX 1448-2E with either varieties of cassava were similar (2.33%), while the intercrops of NR 8230 (2.45%) was significantly ($P < 0.05$) higher than TMS 30572 intercropped with Samsoy-2 (2.40%), (early maturing variety) TGX 1894-3E (2.55%) and TGX 1805-31F (2.30%), (medium maturing varieties) and at late maturing varieties, intercrops of TMS 30572 with both soybean varieties out yielded intercrops of NR 8230. At early maturing variety, highest leaf-K (2.45%) was obtained at NR 8230 intercropped with Samsoy-2 while at medium

maturing varieties, NR 8230 intercropped with TGX 1894-3E gave the highest leaf-K (2.55%). At late maturing variety, the highest leaf-K was obtained with TMS 30572 intercropped with TGX 1864-17F (2.38%).

DISCUSSION

The importance of inclusion of potassium was shown where the highest parameters were obtained at N_0K_{50} and $N_{45}K_{50}$ fertilizer rates. Increasing the K^+ available to the plants (N_0K_{50} and N_{45} K_{50} fertilizer rates) caused significant increase in the cassava tuber yield at more than other fertilizer rates (N_0K_0 and N_{45} K_0) where there was no K^+ in the fertilizer. Tarrace and Gieiger (1982) made similar observation and reported that increased K^+ nutrition on sugar beet plants promoted the translocation of products of photosynthesis, affect the metabolic conversion of sucrose in the sink tissues and resulted in net carbon increase and C/N ratio. An increase in the supply of K^+ in the plant root zone by fertilization (N_0K_{50} and $N_{45}K_{50}$) increased K^+ accumulation in source leaves and caused increase in cassava tuber yield. The amount of K^+ in cassava leaf was between 1.5 – 3.5%, while tuber yield was 2.0 – 45.0 $t.ha^{-1}$. The role of K^+ as a cofactor in synthetic metabolism has been well established (Rains 1976). The increased K^+ at the sink region may enhance the conversion of sucrose to synthesized metabolites and thus promote translocation into those sinks with enhanced K^+. There was also enhancement of synthesis of protein, lipids and cell wall in the growing plant resulting from K^+ supply as reported by Mengel and Haeder (1977). This observation explains why nitrogen fertilizer or biological nitrogen fixation (BNF) alone did not achieve the highest growth and yield of cassava. Also, it has been reported that the imbalance between exchangeable K and other soil minerals, notably calcium and magnesium, may result in total crop failure (Howeler and Candavid 1983). There was significant ($P < 0.05$) interaction between potassium rate and cropping system. Highest leaf-K (2.9%) was obtained at $N_{45}K_{50}$ x

TMS 30572 intercropped with TGX 1894-3E, TMS 30572 intercropped TGX 1864-17F, N_0K_{50} x NR 8230 intercropped with Samsoy-2 and TMS 30572 intercropped with TGX 1889-12F. Lowest leaf-K was obtained at N_0K_0 x all the varieties and cropping system. Highest leaf-K was obtained at N_0K_{50} and $N_{45}K_{50}$ fertilizer rates. Without K fertilization (N_0K_0 and $N_{45}K_0$), residual soil potassium was very low. Howelar and Candavid (1983) reported also that even if the stems and leaves of cassava were returned to the soil, there would still be a considerable net loss of K from the soil because much K is removed by the cassava roots and fresh tuber. CIAT (1981) reported that without adequate K fertilization in cassava, there was yield decline.

CONCLUTION

The highest cassava tuber yield (42.0 $t.ha^{-1}$) was obtained with the fertilizer rate of N_0K_{50} x NR 8230 intercropped with TGX 1894-3E. Cassava leaf-K at N_0K_{50} was significantly higher than other fertilizer rates, while leaf-K at N_0K_0 was the lowest.

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Table 1: Effects of fertilizer rate and cropping system on cassava tuber yield ($t.ha^{-1}$) at 12 MAP

Cropping systems (C)	Fertilizer rates (F)				
	N_0K_0	N_0K_{50}	$N_{45}K_0$	$N_{45}K_{50}$	Mean
NR 8230 Sole	4.2	22.1	24.2	25.6	19.0
TMS 30572 Sole	6.8	20.0	21.4	26.1	18.6
NR 8230/TGX1448-2E	7.1	24.2	17.8	12.4	17.9
TMS30572/TGX1448-2E	13.1	23.5	36.5	35.6	27.2
NR 8230/Samsoy-2	10.5	33.8	30.1	40.5	28.7
TMS 30572/Samsoy-2	12.0	31.5	32.9	16.7	23.3
NR 8230/TGX 1894-3E	15.7	42.0	30.6	34.7	30.8
TMS30572/TGX1894-3E	11.5	38.9	32.6	22.0	26.3
NR 8230/TGX 1805-31F	9.7	38.2	30.4	32.8	27.8
TMS30572/TGX1805-31F	11.8	38.7	27.8	27.8	26.4
NR8230/TGX1889-12F	14.6	35.5	32.6	32.6	28.8
TMS30572/TGX188912F	21.8	32.4	31.6	23.5	27.3
NR 8230/TGX 1864-17F	18.2	25.8	25.8	27.4	24.3
TMS30572/TGX186417F	19.6	23.6	23.6	25.3	21.7
Mean	12.6	30.7	28.4	28.0	

$LSD_{0.05}$ for comparing two Fertilizer (F) means =0.51
$LSD_{0.05}$ for comparing two Cropping system (C) means = 0.58
$LSD_{0.05}$ for comparing two (F x C) interaction means = 1.14

Table 2: Effects of fertilizer rate and cropping system on cassava leaf-K (%) at 12MAP

Cropping systems (C)	Fertilizer rates (F)				
	N_0K_0	N_0K_{50}	$N_{45}K_0$	$N_{45}K_{50}$	Mean
NR 8230 Sole	1.9	2.6	2.1	2.8	2.35
TMS 30572 Sole	1.9	2.7	2.1	2.6	2.33
NR 8230/TGX1448-2E	1.8	2.8	2.2	2.5	2.33
TMS30572/TGX1448-2E	1.9	2.8	2.1	2.5	2.33
NR 8230/Samsoy-2	1.9	2.9	2.2	2.8	2.45
TMS 30572/Samsoy-2	2.0	2.7	2.1	2.8	2.40
NR 8230/TGX 1894-3E	2.1	3.2	2.1	2.8	2.55
TMS30572/TGX1894-3E	1.9	2.6	2.2	2.9	2.40
NR 8230/TGX 1805-31F	1.8	2.5	2.3	2.6	2.30
TMS30572/TGX1805-31F	1.8	2.5	2.2	2.4	2.23
NR8230/TGX1889-12F	1.9	2.6	2.1	2.5	2.28
TMS30572/TGX188912F	1.8	2.9	2.1	2.6	2.33
NR 8230/TGX 1864-17F	1.8	2.6	2.1	2.8	2.33
TMS30572/TGX186417F	1.9	2.6	2.1	2.9	2.38
Mean	1.89	2.71	2.14	2.68	

$LSD_{0.05}$ for comparing two Fertilizer (F) means = 0.01
$LSD_{0.05}$ for comparing two Cropping system (C) means = 0.02
$LSD_{0.05}$ for comparing two (F x C) interaction means = 0.04