WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.7 (2) : 279-282. 2009 *www.world-food.net*

The response of cassava to potassium fertilizer treatments

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Received 2 January 2009, accepted 12 April 2009.

Abstract

The increased production of cassava for poverty alleviation had been advocated for by the Government of Federal Republic of Nigeria. Though the use of fertilizer had been identified as a major input to achieve this, the rising prohibitive fertilizer cost had necessitated investigating into the economic use of fertilizer for optimum cassava production for profit maximization. The response of cassava to varying rates of potassium was therefore investigated in a research conducted in Owo (Latitude 7°11'N, Longitude 5°30'E) in 2006 and 2007. Cassava TMS 30572 variety that matured within ten months was planted in April 2006 and the experiment revalidated in April 2007. The cuttings were planted at a spacing of 50 cm on ridges 90 cm apart. The experimental design was a randomized block replicated three times and the fertilizer treatments were K_2O 150, 120, 90 and 60 kg/ha potassium chloride and control plot without fertilizer application (0 kg/ha). Cassava was harvested at ten months and the yield parameters were taken. Significantly higher yields of 22.9 and 20.8 t/ha were obtained in plots treated with 150 and 120 kg/ha potassium compared with other plots treated with 90, 60 and 0 kg/ha potassium with corresponding yield values of 18.0, 17.6 and 12 t/ha respectively. The increasing rate of potassium fertilizer was positively correlated to cassava yield (r = 0.99) with a linear regression equation of y = 12.3459 + 0.0704x. The net revenues in the plots as treated with K_2O 150, 120, 90, 60, 0 kg/ha were #84,600.00, #70,700.00, #51,500.00, #53,400.00 and #18,500.00, respectively. The higher yield values associated with higher potassium application confirmed the high potassium need for cassava and the improved response of cassava to increasing potassium fertilizer rate.

Key words: Fertilizer application, cassava yield, profitable response.

Introduction

Cassava is a major staple in Nigeria as it is produced both for direct consumption and industrial use [5]. Several recipes of cassava are delicacies in the diet of the people. Gari is prepared for consumption by soaking in cold water or by pouring slowly into a pot of boiling water and eaten with soup. Cassava flour is now added as a component for baking bread and biscuits.

The industrial use of cassava is found in its production as starch more importantly in the recent time as fuel grade ethanol called gasohol. Gasohol has been described as a mixture of 90% unleaded gasoline and 10% ethanol. This mixture has been discussed to reduce the volume of carbon dioxide released into the atmosphere during automobile use. This has been observed to improve air quality and ultimately reduce global warming and its catastrophic consequences [4].

Cassava has a high requirement for potassium as previous research had indicated yield to be apparently limited by a lack of adequate potassium [3]. Previous research also indicated an adequate level of potassium to be necessary for an appreciable response of cassava to nitrogen fertilizer [6]. Potash deficiency has been observed not only to cause reduced yield and lower starch content but also unfavourable effects on the value of the roots for consumption as a result of presence of cyanogenic glucoside that was contained in the roots [3, 5].

The need for increased production of cassava and for a sustained production level has become imperative. The objective of the research was to investigate the improvement of cassava production with varying rates of potash fertilizer.

Materials and Methods

Site description: The research was conducted starting from April 2006 in Owo (Latitude 7°11'N, Longitude 5°30'E). The experiment was repeated at another location of 50 m away, but within the same vicinity in April 2007, in order to revalidate observation. The site was a gentle terrain and had been cropped continuously for three years without fertilizer application. The soil was an alfisol.

Experimental design, land preparation, cassava planting: The experimental design was randomized complete block with three replications. The total area of experiment was 30 m x 20 m with each experimental plot being 5 m x 5 m. The land was ploughed, harrowed and ridged with the ridges made 90 cm apart. Cassava cuttings TMS 30572 variety that matured at ten months were planted in April 2006 at 50 cm apart on the ridges to give a plant population of 22,000 stands per hectare.

Fertilizer treatments: A basal dose of 100 kg/ha NPK 12–12–0 fertilizer which contained no potassium was ploughed in during the land preparation to supply nitrogen and phosphorus. The NPK 12–12–0 was formulated by blending together 26 kg/ha urea (46% nitrogen) with 60 kg/ha single super phosphate (20% P_2O_5) using a mechanical mixer.

Muriate of potash (KCl) which contained 60% potassium was applied at rates of K_2O 150, 120, 90, 60 and 0 kg/ha as band at 10 cm from cassava stand at three weeks after planting. This gave a corresponding weight of 6.8, 5.4, 4.1, 2.7 and 0 g muriate of potash per cassava plant for the K_2O 150, 120, 90, 60 and 0 kg/ha treatment plots respectively at cassava spacing of 90 cm x 50 cm.

Soil sampling and analysis: Pre-treatment soil samples for soil analysis were taken before land preparation and fertilizer treatment to show the soil fertility status before the commencement of experiment. Soil samples were air-dried and sieved through a 2-mm sieve and analysed following the laboratory procedures of Canadian Society of Soil Science [2]. The particle size distribution analysis was performed using 50 g of soil in 0.1 M NaOH as dispersing agent. Hydrometer ASTM 1524 readings were taken at 40 seconds and at 2 hours. The soil pH was determined in water using a glass electrode pH meter. Organic carbon was determined by oxidising soil sample with dichromate solution and titrating with ferrous sulphate solution. The total nitrogen was determined using micro-Kjeldahl method and the available phosphorus by the molybdenum blue method. The exchangeable cations were extracted by leaching 5 g of soil with 50 ml of ammonium acetate at pH 7. The potassium and sodium in the leachate were determined with a column Model 21 flame spectrophotometer and the calcium and magnesium with atomic absorption spectrophotometer. The exchangeable acidity was determined by adding barium chloride buffer solution to soil sample and titrating against 0.1 N HCl.

Statistical analysis: The yield values were subjected to statistical analysis and the mean comparisons made using Duncan Multiple Range Test (DMRT) at 5% probability. The profitable analysis based on income and expenditure on cassava production at the varied potassium rates was also computed.

Results and Discussion

The commencement of the experiment in April was to ensure adequate moisture in the soil as the rainy season in the area was from April to October. Figs 1a and 1b showed the chart of rainfall distribution, relative humidity and temperature regime of Akure, a town close to Owo in 2006 and 2007, respectively. In the two years, the rainy and dry seasons were distinctly identified. In 2006, the months of November to February were dry compared to other months while the months with higher rainfalls were April and August with 243.5 and 213.7 mm, respectively.

Even though the temperature did not follow a corresponding trend with rainfall, the months of May to October had lower values that ranged from 25.1 to 27.3°C when compared to higher range of 27.7 to 28.6°C in November to April. A similar climatic trend was observed in 2007 (Fig. 1b). Akintola [1] in a previous study of rainfall distribution in Nigeria for a period of 1892 to 1983 (91 years) confirmed the need for steady rainfall before commencement of farming practices particularly for rainfed crop production.

The repeat of the experiment in April 2007 was to revalidate results. The repeated experiment was sited in the same vicinity but 50 m away to that conducted in April 2006 in order to have the same influence of climate, organism, parent material and relief as factors of soil formation. The experiment location was shifted in order to avoid the residual effects of the fertilizers applied in the previous year. The mean yield values of the two years were statistically analyzed as presented in Fig. 3.

Fig. 2 shows the experimental layout and the randomness of the treatment plots replicated three times. Each treatment plot was 5 m x 5 m to give a plant population of 22,000 per hectare. The ridges in each plot were 90 cm apart while the cassava cuttings were spaced 50 cm on the ridges. A buffered discard space of 1 m was created round each treatment plot.

The results of the pre-treatment soil analysis which indicated the original soil fertility status before land preparation and fertilizer treatment showed pH 5.8, 1.2% organic matter, 9 ppm phosphorus, 0.12% nitrogen, 0.12 cmol/kg potassium, 1.89 cmol/kg calcium and 0.24 cmol/kg magnesium. The soils were moderately acidic with low organic matter, total nitrogen, calcium, magnesium and potassium. The low fertility status was due to the continuously cropping of the land without fertilizer application to replenish lost nutrients.

The low levels of nitrogen and phosphorus were beefed up with the basal dressing of NPK 12-12–0 during land mechanization of ploughing and harrowing. The low level of potassium of 0.12 cmol/kg would make the varied effects of the added potassium fertilizers to become evident. Tisdale *et al.* [7] applied Mitscherlich's equation to explain the assertion that when plants were supplied with adequate amounts of all but one nutrient, the growth of the plants would be proportional to the amount of the one limiting element.

The land preparation that involved ploughing, harrowing and ridging was to ensure a pulverized soil. Cassava being a tuber crop would require pulverized uncompacted soil to produce big tubers that would meet consumer's preference. Onwueme [5] discussed that the fibrous roots of cassava would first penetrate the soil before they enlarge to become tuberous and therefore a ploughed, harrowed and ridged soil would ensure soil penetration of the cassava roots.

The relationship between cassava yield and potassium rates was linear and positively correlated ($r = 0.99$) with a regression equation $y = 12.3459 + 0.0704x$. Increasing potassium rate resulted in higher cassava yield. Significantly higher yield values of 22.9 and 20.8 t/ha were obtained in plots treated with 150 and 120 kg potassium per hectare respectively compared with other treatment plots. There was no significant difference between plots treated with K_2O 90 and 60 kg/ha while the plot without potassium fertilizer (0 kg/ha) had significantly lower yield value of 12 t/ha, as displayed with the error bars (Fig. 3).

The profitable response is shown in Table 1. The yield values of 22.9, 20.8, 18 and 17.6 t/ha in plots treated with K_2O 150, 120, 90 and 60 kg/ha gave an increase of 90.3, 73.3, 50.0 and 46.7% over 12 t/ha obtained in plots without potassium fertilizer. The corresponding net revenue on cassava tuber sales was #84,600.00, #70,700.00, #51,500.00, #53,400.00 and #18,500.00 in plots treated with K_2O 150, 120, 90, 60 and 0 kg/ha, respectively.

Conclusions

Cassava yield improved with the application of potassium fertilizer. Maximum yield of 22.9 t/ha with a net revenue of #84,600.00 was obtained with the application of K_2O 150 kg/ha while significantly lower value of 12 t/ha with a net revenue of #18,500.00 was obtained in the plot without potassium fertilizer giving an increase of 357.3% whereas all agronomic practices of farm maintenance were carried out.

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Table 1. The profitable response of cassava yield to varying rates of potassium fertilizer.

S/N	Farm operation	Cost (#)* K_2O 0 kg/ha	Cost (#)* K_2O 60 kg/ha	Cost (#)* K_2O 90 kg/ha	Cost (#)* K_2O 120 kg/ha	Cost (#)* K_2O 150 kg/ha
1	Land preparation (ploughing, harrowing, ridging)	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
2	Cassava cuttings (60 Bundles @ #300/bundle)	18,000.00	18,000.00	18,000.00	18,000.00	18,000.00
3	Planting (8 pd** at #500.00/pd)	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00
4	Purchase of NPK 12 – 12 - 0	10,000	10,000	10,000	10,000	10,000
5	Application of fertilizer	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00
6	Purchase of potassium fertilizer	Nil	11,500.00	17,000.00	23,000.00	28,800.00
7	Application of fertilizer	Nil	4,000.00	4,000.00	4,000.00	4,000.00
8	Purchase of Cotoran insecticide (2 litres at #1,000.00)	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
9	Application of insecticide	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
10	Purchase of Primextra (Pre-emergence)	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
11	Application of herbicide	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
12	One supplementary weeding (20 pd** at #500.00/pd)	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
13	Harvesting	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00
14	Total cost of production	87,500.00	103,000.00	108,500.00	114,500.00	120,300.00
15	Yield (kg/ha)	12,000.00	17,600.00	18,000.00	20,800.00	22,900.00
16	Gross revenue at #9.00/kg	108,000.00	158,400.00	162,000.00	187,200.00	206,100.00
17	Net revenue	20,500.00	55,400.00	53,500.00	72,700.00	85,800.00
18	% Increase in yield	Nil	46.66	50.00	73.33	90.83
19	% Increase in net revenue	Nil	170.24	160.97	254.63	318.54

*Exchange Rates: 1US Dollar = 120 Nigerian Naira (#120.00) **pd = person days (Farm labour wage).

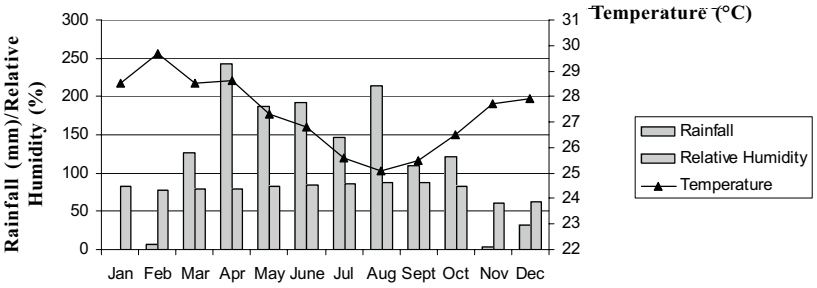

Figure 1a. The chart of rainfall distribution, relative humidity and temperature regime of Akure in 2006.

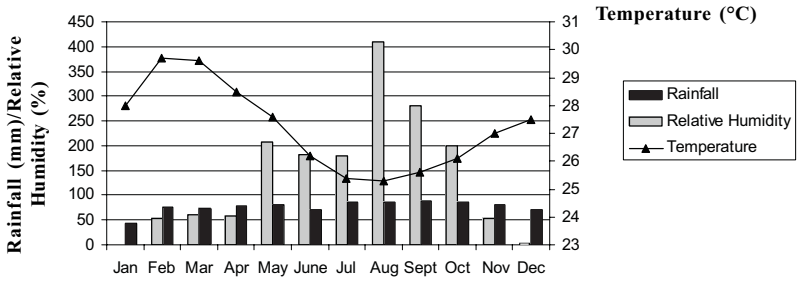

Figure 1b. The chart of rainfall distribution, relative humidity and temperature regime of Akure in 2007.

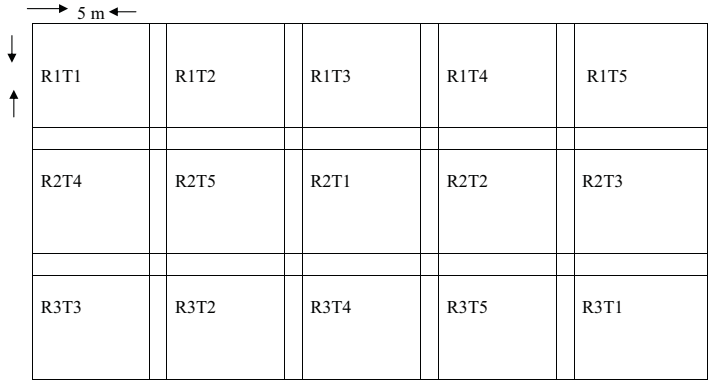

Figure 2. The experimental layout and randomness of treatment plots. R1 = Replicate 1, R2 = Replicate 2, R3 = Replicate 3, T1 = Fertilizer treatment 1 (K_2O 0 kg/ha), T2 = Fertilizer Treatment 2 (K_2O 60 kg/ha), T3 = Fertilizer treatment 3 (K_2O 90 kg/ha), T4 = Fertilizer treatment 4 (K_2O 120 kg/ha), T5 = Fertilizer treatment 5 (K_2O 150 kg/ha).

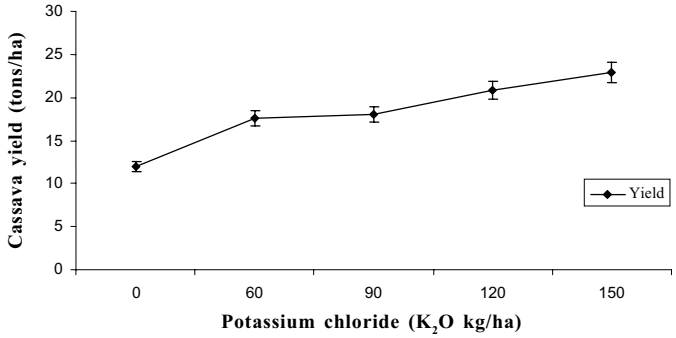

Figure 3. Effects of potassium fertilizer treatments on cassava yield; Fertilizer treatment 1 = K_2O 0 kg/ha, Fertilizer treatment 2 = K_2O 60 kg/ha, Fertilizer treatment 3 = K_2O 90 kg/ha, Fertilizer treatment 4 = K_2O 120 kg/ha, Fertilizer treatment 5 = K_2O 150 kg/ha