**The Journal of Animal & Plant Sciences, 23(2): 2013, Page: 550-555**
**ISSN: 1018-7081**

# CASSAVA (*Manihot esculenta Crantz)* PERFORMANCE AS INFLUENCED BY NITROGEN AND POTASSIUM FERTILIZERS IN UYO, NIGERIA

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## ABSTRACT

Large scale cassava production is today being carried out season after season repeatedly on the same piece of land leading to decline in soil fertility and yield overtime. Research information to guide farmers on appropriate fertilizer management under such continuous cropping are few and poorly documented in south eastern Nigeria. A two-year field experiment was conducted during 2007 - 2009 at Uyo, a humid forest agro-ecology of south eastern Nigeria to assess the growth and yield response of cassava. Treatments included four rates each of nitrogen (N) and potassium (K) (0, 40, 80 and 120 kg/ha) in all possible factorial combination replicated thrice in a randomized complete block design. Application of N at the highest rate significantly (P = 0.05) increased plant height, produced higher number of leaves and branches/plant, stem girth, number and weight of tubers/plant and total fresh tuber yield compared with other treatments. The fresh tuber yield at 120 kg N/ha was however, comparable with that at 80 kg N/ha rate. Cassava growth, fresh tuber yield and all yield attributes peaked at 80 kg K/ha rate. The 120 kg N/ha and 80 kg K/ha rates increased fresh tuber weight by 48 and 45% and total fresh tuber yield by 36 and 27% respectively, compared with the control plots. The application of N between 80 and 120 kg/ha and K at 80 kg/ha appeared appropriate for optimum yield in our study area and are thus recommended.

**Key words:** Cassava, nitrogen, potassium, growth, yield.

## INTRODUCTION

Cassava (*Manihot esculenta Crentz),* a major staple food crop of the people in most parts of Africa, plays an important role in terms of food security, employment and income generation for farm families in parts of the humid tropics. It derives its importance from the fact that it produces more calories/unit area from its starchy tuberous root which is a valuable source of cheap calories especially in developing countries (Som, 2007). Apart from its use as food, it is also an important industrial raw material for the production of starch, alcohol, pharmaceuticals, gums, confectioneries and livestock feed (Nnodu *et al.,* 2006). In many parts of Africa, the leaves and tender shoots are also consumed as vegetables (Eke-Okoro and Dixon, 2000). Ethanol from cassava is used as biofuel in most of the developed world because it causes no air pollution or environmental hazard.

Cassava has earned the reputation of being well adapted to soils of low fertility. This stems from its ability to produce some yield, however low, in subsistence agricultural systems on soils of low fertility status and this has contributed greatly to its success over other staple food crops. For this reason, peasant farmers do not fertilize cassava as they are contented with the minimal yield obtained from using limited inputs from their poor soils.

Presently, cassava has attained the status of an industrial crop in Nigeria. It is now being grown on large scale, repeatedly season after season on the same piece of land. Under this condition, the fertility of the soil and yields declined overtime (Nguyen, *et al.,* 2001). Decline in soil fertility is especially serious in tropical regions where the soil lacks adequate plant nutrients and organic matter due to leaching and erosion of top soil by intense rainfall (Ayoola and Makinde, 2007). Cassava extracts substantial amounts of nutrients with the harvested roots, the highest being K, followed by N, Ca, Mg and P; and if not adequately fertilized, will exhaust soil nutrients under continuous cropping (Pellet and Sharkawy, 1993; Nguyen, *et al.,* 2001). Thus, sustainable continuous production of cassava on the same piece of land would require the application of supplementary nutrients.

Cassava plant is well adapted to low levels of available P (on account of its mycorrhizal association which makes P available to it) but requires fairly high levels of N and K, especially when grown for many years on the same plot or continuously cultivated plots (Howeler *et al*., 2000; Ayoola and Makinde, 2007). Cassava crop producing a yield of 30t/ha extracts 187 kg N, 33 kg P and 233 kg K/ha (Som, 2007). Optimum root yield was obtained by applying 90 kg N, 18 kg P and 75 kg K/ha on *Ultisols* testing low in N and K and medium in P (NRCRI, 1990). Result from NRCRI (2005), indicated that N application at 80 kg/ha gave the highest growth and yield compared to the control and 120 kg/ha rate. In a 3-year trial by Kang *et al.,* (1981) at Onne, Nigeria, it was concluded that for continuous cassava production, a maintenance dressing of 60 kg K/ha per cropping season may be adequate. Evangelio *et al.,* (1995) reported significant yield increases in cassava due to N and K fertilization in the $2^{nd}$ uptil the $4^{th}$ cropping cycles in Philippines. Apart from increasing yield, high K application has been shown to improve dry matter and starch content and reduce the hydrocyanic acid (HCN) content of cassava roots (El-Sharkawy and Cadavid, 2000; Susan John *et al*., 2005; Okpara, *et al*., 2010)

Fertilizer trials on cassava are rare in Akwa Ibom State, Nigeria and the newly released varieties for the zone by the International Institute of Tropical Agriculture (IITA), have not been subjected to fertilizer studies for optimum nutrient requirements. This study was therefore conducted to evaluate the growth and yield response of one of the improved varieties to N and K fertilizers in the south eastern agroecology of Nigeria.

## MATERIALS AND METHODS

The experiments were conducted during May, 2007 to March 2009 in Use-Offot, the Teaching and Research Farm of the University of Uyo, south eastern Nigeria (5º 18¹ and 5º 28¹ N, 7° 26 and 7º 57¹E; 65m altitude). Uyo has a mean annual rainfall of about 2500mm during the rainy season which extends from March to November, mean relative humidity of 78% and mean annual minimum and maximum temperatures of 22.5 and 30.7ºC (IITA,1998). Meteorological data during the two cropping seasons are presented in Table 1. The soil was acidic and belongs to broad soil classification group *Alfisol,* with well drained coastal plain sands of Benin formation, low in organic matter, nitrogen, potassium and other nutrients (Ohiri *et al.,* 1989; Brady and Weil, 1996).

The sites for the study had been in cultivation for some years with maize *(Zea mays L.),* fluted pumpkin (*Telfairia occidentalis* Hook. F.), garden egg (*Solanum gilo* Raddi*)* and Cassava (*Manihot esculenta Crantz)* before being left fallow for about two years prior to commencement of the experiments. Treatments comprised of four rates of nitrogen (N) (0, 40, 80 and 120 kg/ha), factorial combination of four rates of potassium (K) (0, 40, 80 and 120 kg/ha) arranged in randomized complete block design with three replicates. Phosphorus at the rate of 30 kg/ha was also applied uniformly to all the plots. Fresh site was used each year.

Gross plot size was 5 x 5m ($25m^2$) and the net plot from where growth and yield attributes were measured was 3 x 3m ($9m^2$). Plots were separated by paths of 1m while blocks were kept apart by 1.5m alley ways. Before land preparation, soil samples were taken at 0-30cm depths from the experimental sites and analyzed for physico-chemical properties using standard procedures described in IITA (1982) (Table 2).

The sites were slashed and cleared manually without burning, ploughed to a depth of 20cm and harrowed once before planting on the flat on 2$^{nd}$ and 4$^{th}$ May respectively, in 2007 and 2008. Planting material consisting of stem cuttings, 20cm in length of an improved early- maturing and low-branching TMS 98/0581 cassava variety obtained from Akwa Ibom State Agricultural Development Programme (AKADEP) Uyo, were planted one cutting per stand slanting at an angle of about 45º with a spacing of 1m x 1m. All the P and K with half of the N for each treatment were applied through banding 8 weeks after sowing (WAS) using single super phosphate, muriate of potash and urea respectively. The second split of urea was top-dressed 14 WAS via ring application. Weeding was carried out manually using native hoe at 3, 7 and 13 WAS. Harvesting was done at the on set of rains in March of both 2008 and 2009, 11 months after sowing by carefully digging out the tubers with native hoe.

From the 9 plants in the net plot areas, yield and yield components were determined. Parameters measured were plant height, number of leaves and branches per plant, stem girth, number of days to 50% flowering, number of tubers/plant, length of tubers/plant, girth of tubers/plant, weight of tubers/plant and total fresh tuber yield. Data generated were subjected to analysis of variance (Snedecor and Cochran, 1968). Treatment means were compared using the Duncan's Multiple Range Test (Duncan, 1965).

## RESULTS AND DISCUSSION

On the basis of averages of data from the two growing seasons 2007 and 2008, plant height, number of leaves and branches/plant and cassava stem girth were significantly increased across N and K rates (Tables 3 and 4). The tallest plants were obtained at 120 kg N/ha and 80 kg K/ha rates. The number of leaves and branches per plant and stem girth followed a similar trend. The control plots recorded the shortest plants with the lowest number of leaves and branches and least stem girth. The superior growth attributes obtained with high rates of N and K in this study have been reported by other workers (NRCRI, 2005 and Dkhil *et al.,* 2011). The positive response of growth characters to the applied nutrients is attributable to their role in cell multiplication and photosynthesis which gave rise to increase in size and length of leaves and stems. The favourable response also confirmed the essentiality of N and K in plant growth and development (Mengel and Kirkby, 2001). This result is in harmony with the findings of Nguyen, *et al., (*2001) and Ayoola and Makinde (2007).

Each incremental rate of N resulted in a corresponding reduction in the number of days to 50% flowering, while the opposite was the case for K treatment in which plants in the control plots flowered earliest (Table 5). The earliness in flowering as a result of N application is indicative of the role of N in promoting vigorous foliage growth, increasing meristematic and more intense physiological activities in the plant which favoured the synthesis of more assimilates and early flowering. This result is consistent with those of Ayoola and Makinde (2009); Orosz *et al., (*2009) and Uwah *et al.*, (2011). The delay in flowering in plants supplied with K may be as a result of its crucial role in active meristematic growth (Mengel and

Kirkby, 2001). The number and weight of tubers/plant and total fresh tuber yield peaked at 120 kg N/ha rates, but the total fresh tuber yield obtained at 80 and 120 kg N/ha rates were however, statistically similar (Table 5). The number, length, stem girth and weight of tubers/plant and total fresh tuber yield were significantly increased by K application up to the 80 kg/ha rate and not beyond. On average, the application of 40, 80 and 120 kg N/ha, increased the number of tubers/plant by 8, 17 and 38%, whereas the same rates for K gave corresponding values of 19, 34 and -1%, respectively over the control. Similarly, weight of tubers/plant at 40, 80 and 120 kg N, and K/ha rates increased by 0.6, 13 and 48%, and 11, 45 and 5% respectively, over those in the control plots. Total fresh tuber yield obtained at 120 kg N/ha rates showed an increase of only 5.6% over that of 80 kg N/ha rate whereas increasing K rates from 0 to 40 kg, increased yield by 20%; a further increase to 80 kg/ha increased tuber yield by 27 percent. Further increase to 120 kg/ha, however, resulted in a significant yield reduction of 23% below the 80 kg/ha rate.

The positive response shown by yield parameters to N and K could be directly linked to the well-developed photosynthetic surfaces and increased physiological activities leading to more assimilates being produced and subsequently translocated and utilized in rapid tuber development and production. Both N and K have been shown to be necessary for cassava root initiation; increase in tuber size and number (Howeler *et al.*, 2000; Ayoola and Makinde, 2007). Nitrogen increases the chlorophyll of leaves thereby promoting the photosynthetic capacity of the plant, plays a part in the manufacture of proteins and is also responsible for high yield in plants. Potassium on

**Table 1: Meteorological data at the trial sites during 2007-2009 seasons at Uyo**

| Month | Rainfall (mm) | | | Average Temperature ($^0$C) | | | Relative Humidity (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2007 | 2008 | 2009 | 2007 | 2008 | 2009 |
| January | 0.0 | 0.0 | 81.6 | 26.5 | 26.7 | 28.1 | 50.5 | 73.0 | 80.0 |
| February | 35.6 | 50.5 | 85.2 | 24.1 | 28.8 | 28.5 | 68.5 | 70.0 | 80.0 |
| March | 178.3 | 260.0 | 59.9 | 28.4 | 28.2 | 29.0 | 68.5 | 82.0 | 79.6 |
| April | 373.3 | 300.0 | 280.2 | 26.8 | 27.5 | 28.0 | 77.5 | 82.0 | 82.2 |
| May | 360.6 | 370.0 | 290.8 | 26.2 | 27.3 | 27.5 | 75.5 | 88.0 | 78.4 |
| June | 466.8 | 465.0 | 340.4 | 26.2 | 26.5 | 26.8 | 81.5 | 89.0 | 85.2 |
| July | 387.9 | 597.7 | 159.9 | 24.4 | 25.6 | 26.0 | 81.0 | 91.0 | 86.0 |
| August | 311.3 | 510.2 | 207.9 | 24.6 | 25.8 | 25.6 | 82.5 | 90.0 | 86.2 |
| September | 393.7 | 217.9 | 225.2 | 25.7 | 26.6 | 26.2 | 82.0 | 88.0 | 85.4 |
| October | 365.4 | 315.5 | 167.1 | 26.5 | 26.8 | 26.4 | 78.5 | 90.0 | 82.6 |
| November | 353.9 | 201.5 | 549.1 | 27.2 | 25.6 | 26.4 | 78.5 | 78.9 | 79.2 |
| December | 80.4 | 3.3 | 0.0 | 27.1 | 26.9 | 27.0 | 76.0 | 78.3 | 80.5 |
| Total | 3307.2 | 3291.1 | 1947.3 | 313.7 | 322.3 | 325.5 | 900.5 | 1000.2 | 985.3 |
| Mean | 275.6 | 274.3 | 162.3 | 26.1 | 26.9 | 27.1 | 75.0 | 83.4 | 82.1 |

**Source**: Department of Geography and Regional Planning, University of Uyo, Nigeria.

**Table 2. Physico-chemical properties of top soil (0-30cm) of experimental fields at Uyo.**

| Composition | 2007 | 2008 |
|---|---|---|
| **Physical composition (g/kg)** | | |
| Sand | 897.30 | 870.30 |
| Silt | 42.70 | 54.70 |
| Clay | 60.00 | 75.00 |
| Textural class | Sandy loam | Sandy loam |
| **Chemical characteristics** | | |
| pH ($H_2O$) (1:2.5) | 5.50 | 6.25 |
| Organic Carbon(g/kg) | 13.50 | 14.10 |
| Available P (mg/kg) | 79.70 | 49.83 |
| Total N (g/kg) | 0.60 | 0.60 |
| **Exchangeable bases (cmol/kg)** | | |
| Ca | 3.00 | 2.56 |
| Mg | 1.30 | 1.10 |
| K | 0.08 | 0.06 |
| Na | 0.05 | 0.05 |
| EA | 2.10 | 2.40 |
| ECEC | 7.20 | 6.16 |
| BS (g/kg) | 615.28 | 612.01 |

the other hand, promotes $CO_2$ assimilation and the translocation of carbohydrates from leaves to the tubers and tuberous roots of crops where carbohydrates are the main storage material (Mengel and Kirkby, 2001). Adequate supply of K is important for starch synthesis and translocation, and it also increases yield and improves tuber quality (Mehdi *et al.,* 2007). Hence, the positive response of tuber yield and yield components to increased rates of N and K could be adduced to high starch synthesis and translocation activities stimulated by N and K application. Moreso, the experimental soils were low in these two nutrients, hence the positive response observed. Optimum root yield of cassava was obtained by applying 90 kg N/ha and 75 kg K/ha (NRCRI, 1990). Evangelio *et al.,*(1995), also reported significant differences in yield of cassava due to N and K application while the best yield and yield attributes was obtained with 80 kg N/ha (NRCRI, 2005). Our results are in conformity with the findings of these various workers and consistent with those of Kang *et al.*, (1981) and Evangelio *et al*., (1995) who suggested that a maintenance dressing of 80 kg N/ha and 60 kg K/ha per cropping season may be adequate for continuous cassava production.

**Table 3. Effect of nitrogen and potassium on plant height (cm) and number of leaves/plant of cassava in 2007 - 2009 at Uyo.**

| | Plant height | | | Number of leaves/plant | | |
|---|---|---|---|---|---|---|
| **Treatment** | **10** | **16** | **22** | **10** | **16** | **22** |
| **Nitrogen (kg N/ha)** | | | | | | |
| 0 | 38.12 | 94.79b | 124.54b | 20.76 | 37.58 | 67.45b |
| 40 | 39.04 | 97.37b | 128.84b | 22.66 | 39.73 | 84.21ab |
| 80 | 39.91 | 101.97b | 132.11b | 22. 88 | 44.99 | 90.34a |
| 120 | 40.60 | 111.46a | 158.61a | 23.66 | 47.12 | 96.13a |
| SE± | 2.127 | 3.192 | 7.733 | 1.012 | 2.988 | 6.645 |
| **Potassium (kg K/ha)** | | | | | | |
| 0 | 30.05b | 83.41c | 123.43b | 19.99c | 34.63b | 70.32b |
| 40 | 43.86a | 104.78ab | 129.68b | 24.20ab | 39.26b | 79.95b |
| 80 | 41.33a | 112.52a | 155.88a | 24.58a | 54.56a | 102.47a |
| 120 | 34.42b | 96.55b | 132.11b | 21.19c | 40.97b | 85.39ab |
| SE± | 2.127 | 3.192 | 7.733 | 1.012 | 2.988 | 6.645 |
| **Interaction** | | | | | | |
| N x K | NS | NS | NS | NS | NS | NS |

Mean followed by same letter(s) within a column are not significantly different at 5% level using DMRT.
NS = Not significant

**Table 4. Effect of nitrogen and potassium on number of branches/plant and stem grith (cm) of cassava in 2007 to 2009 at Uyo.**

| | Number of branches/plant WAS | | | | Stem girth (cm) WAS | | | |
|---|---|---|---|---|---|---|---|---|
| **Treatment** | 12 | 16 | 20 | 22 | 12 | 16 | 20 | 22 |
| **N (kg K/ha)** | | | | | | | | |
| 0 | 2.67 | 3.88b | 5.00c | 6.63b | 5.57 | 6.03b | 6.95 | 7.13b |
| 40 | 3.13 | 3.97b | 5.65b | 7.31b | 5.68 | 6.08b | 7.02 | 7.16b |
| 80 | 3.58 | 4.76ab | 6.04ab | 10.44a | 6.05 | 6.14b | 7.06 | 7.58a |
| 120 | 3.58 | 5.39a | 6.33a | 12.43a | 6.28 | 6.86a | 7.65 | 7.92a |
| SE± | 0.316 | 0.357 | 0.185 | 0.882 | 0.390 | 0.222 | 0.254 | 0.123 |
| **K (kg K/ha)** | | | | | | | | |
| 0 | 2.38b | 4.23 | 5.54 | 7.11c | 5.57 | 5.83b | 6.62b | 7.01 |
| 40 | 3.67a | 4.56 | 5.71 | 10.31ab | 6.13 | 6.37ab | 7.10b | 7.38 |
| 80 | 3.75a | 4.82 | 6.07 | 11.68a | 6.13 | 6.94a | 7.90a | 8.13 |
| 120 | 3.13ab | 4.39 | 5.71 | 8.22bc | 5.75 | 5.98b | 7.06b | 7.25 |
| SE± | 0.316 | 0.357 | 0.185 | 0.883 | 0.390 | 0.222 | 0.254 | 0.123 |
| **Interaction** | | | | | | | | |
| N x K | NS | NS | NS | NS | NS | NS | NS | NS |

Means followed by the same letter(s) within a column are not significantly different at 5% level using DMRT.
NS = Not significant

**Table 5. Effect of nitrogen and potassium on yield attributes of cassava in 2007 to 2009 at Uyo.**

| Treatment | No. of days to 50% flowering | No. of tubers/plant | Length of tubers/plant (cm) | Girth of tubers/plant (cm) | Weight of tubers/plant (g) | Total fresh tuber yield (t/ha) |
|---|---|---|---|---|---|---|
| **N (kg K/ha)** | | | | | | |
| 0 | 1075.00a | 6.52c | 34.17 | 16.07 | 290.31b | 20.59c |
| 40 | 972.50b | 7.04bc | 34.28 | 16.66 | 292.05b | 25.11b |
| 80 | 960.00b | 7.60b | 35.96 | 16.79 | 328.92b | 26.43ab |
| 120 | 915.00b | 9.00a | 36.54 | 16.84 | 430.55a | 27.90a |
| SE± | 33.778 | 0.302 | 2.230 | 0.575 | 21.878 | 1.229 |
| **K (kg K/ha)** | | | | | | |
| 0 | 805.00b | 6.67c | 29.53b | 15.34b | 312.45b | 21.97b |
| 40 | 1030.00a | 7.95b | 37.38a | 17.46a | 346.00b | 26.47a |
| 80 | 1037.50a | 8.95a | 38.60a | 17.88a | 453.89a | 27.89a |
| 120 | 1050.00a | 6.59c | 35.43ab | 15.67b | 329.56b | 22.70b |
| SE± | 33.778 | 0.302 | 2.230 | 0.575 | 21.878 | 1.229 |
| **Interaction** | | | | | | |
| N x K | NS | NS | NS | NS | NS | NS |

Means followed by the same letter(s) within a column are not significantly different at 5% level using DMRT.
NS = Not significant

**Conclusion:** The findings of the study showed that nitrogen and potassium had positive effects on growth and yield of cassava as they significantly enhanced its production. The application of N between 80 and 120 kg/ha and K at 80 kg/ha appeared appropriate for optimum yield in our study area. Fertilization of cassava on these soils would require N and K in the fertilizer regime unless the inherent levels of these nutrients are shown to be adequate from pre-sowing soil analysis.

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