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Nitrogen and Potassium Status of Selected Soils and Their Effects on the Growth, Yield and Cyanide Content of Cassava (*Manihot esculenta Crantz*) in Delta State, Nigeria

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Abstract: This study was conducted to evaluate the nutrient status and the effects of Nitrogen and Potassium fertilizer on the growth, yield and Hydrogen cyanide content of cassava (*Manihot esculenta* (L) Crantz) in Delta State, Nigeria; Representative soil samples were obtained from Abraka, (Rainforest zone); at 0-15cm and 15 -30cm depths. These were analyzed for their physical and chemical properties. The design was a 4×4 factorial scheme fitted into a Randomized Complete Block design giving 16 treatment combinations with 3 replicates. The following treatment combinations of N and K were applied: N_0K_0(no fertilizer), N_0K_{20}, N_0K_{40}, N_0K_{80}, $N_{40}K_0$, $N_{40}K_{20}$ $N_{40}K_{40}$, $N_{40}K_{80}$, $N_{80}K_0$, $N_{80}K_{20}$, $N_{80}K_{40}$, $N_{80}K_{80}$, $N_{120}K_0$, $N_{120}K_{20}$, $N_{120}K_{40}$, and $N_{120}K_{80}$ kg/ha^{-1} The plant parameters measured were: plant height. These were taken at 2,4,6,8 and 10 months after planting (MAP). Fresh tuber weight and Hydrogen content of tuber were also determined. In the trials involving the application of N, K and their combinations, K had significant effect 2-10 MAP on plant height at *($p<0.05$)* influenced *fresh tuber* weights of cassava. It was concluded that 120kgN/ha in combination with 20kgK/ha be applied to soils in the study area for the cultivation of cassava variety for best tuber yields and hydrogen cyanide content.

Keywords: cassava, treatment, fertilizer, growth characters, yield.

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INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a woody root crop which belongs to the family Euphorbiaceae and takes it centre of origin from Brazil, South America. It is widely grown in both tropical and sub-tropical regions of the world mainly for its edible starchy storage roots (Henry, C. 2006). Cassava is an important source of dietary carbohydrate and provides food for over half a million people in Nigeria (Bassey, E. E. 2016). Omoregie (Omoregie, A. U. 2005) reported that cassava serves some useful economic purposes; these include:

- *garri*, the traditional product which is consumed in granule form,
- *fufu/akpu* which has assumed a national spread in consumption,
- tapioca and *usi* (starch) which are delicacies among the Urhobos, Itsekiris, and Ijaws of the Niger Delta, materials for industrial and domestic uses,
- the leaves which are used as vegetable and
- chips which are used for livestock feed.

The roots contain about 25 to 35 percent starch, the leaves, although not important in some areas, contain a significant amount of protein and some mineral nutrients (Azaino, E. 2008). Cassava has long played a very important role in ensuring food security, particularly in Sub-Saharan Africa, where food security is a problem. Nigeria currently is positioned as the world largest cassava producer, followed by Thailand, Indonesia and Brazil (Food & Agricultural Organization FAOSTAT. 2016).

Responses of cassava to fertilizer application are very variable under different nutrient and climatic conditions (Leakey, C. L. A., & Wills, J. B. 1977). Nair and Sadananadan (Nair, S. M. & Sadananadan, J. E. 1985) reported that N and K applications increased the yield obtained by applying 90kgN, 18kg P and 75kgK/ha on Utisol testing low in N and K and medium in P. Highest rate of tuberization and yield response were obtained with a combination of several levels of NPK 15:15:15 at 60, 90 and120 days (CIAT. 1985). Nigerian soils are fragile and inherently infertile (Agboola, A. A., & Unamma, R. P. A. 1991). This infertile nature of the soils has led to reduction in yields, and resource – poor farmers are unable to meet national food demands. All that is required is to sustain the fertility of the soils and modify or improve on them (Agboola, A. A., & Unamma, R. P. A. 1991).

To increase the yield potential of cassava, the crop had been reported to respond to good soil fertility and adequate fertilizer (Gomez, J. C. *et al.,* 1980). Farmers do not fertilize cassava because they are contented with the minimal yields obtained from it using limited inputs or even from their infertile soils. The indifference towards low productivity can be attributed to the low and unstable prices of cassava tubers. However, fertilizer requirement for optimum yield in cassava is determined by soil fertility status of the farmland, intensity and soil improve the cassava yield. Potassium level in soil stimulates response to N cropping K levels in fertilizers but excess amount of both nutrients leads to luxuriant growth at the expense of tuber formation (Madhava, R. D. *et al.,* 1986; Onwueme, I. C., & Charles, W. B. 1994;). It is therefore necessary to embark on aggressive cassava production in this agro-ecology to ensure that Nigeria attains sufficiency in cassava production. This can be achieved mainly by cultivating improved and adaptable cassava cultivars. In order for cassava to reach its full production capacity, there is need to address nutrient deficiency. Reports on the nutrient requirements and response of cassava to fertilizer in Delta State, Nigeria are limited. Consequently, there is need to provide information on the missing link for better production of cassava in Delta State. Therefore, this study was conducted to assess the effects of nitrogen and potassium status of selected soils and their effects on the growth, yield and cyanide content of cassava in Delta State, Nigeria.

MATERIALS AND METHODS:

❖ **Location:**

The study was carried out in Delta State, Nigeria. Delta State which lies in the geographical coordinates of 6° 18' 0" N, 6° 23' 0" E in the Greenwich meridian. Rainfall occurs mainly from April to October. Annual rainfall is usually from 2000mm – 3000mm with an intense sunlight, which lasts for a minimum of 8 hours daily. Temperatures are high for most parts of the year, especially in the months of November to April with a mean monthly temperature of 31°C. The annual range of temperature is thus small, only varying between 30°C and 50°C. Relative humidity varies from 60% during dry season to about 90% in the rainy. The experiment was done at Abraka because N and K were found to be deficient, from soil analysis.

❖ **Land Preparation and Fertilizer Application:**

The land used for the experiment was manually cleared, and debris packed without burning. Nitrogen and Potassium were applied at rates of 0, 40, 80 and 120 kgN/ha and 0, 20, 40 and 80 kgK/ha, respectively. The applications were made based on N and K contents of the soil resulting from soil analysis. Nitrogen was applied as urea while Potassium was applied as muriate of potash.

A proven variety of cassava TME (419) obtained from the International Institute for Tropical Agriculture (IITA) Ibadan was used in this study. The design was a 4 x 4 factorial scheme fitted into a randomized complete block design giving sixteen treatment combinations with three replicates. The following treatment combinations were applied N_0K_0kg/ha, N_0K_{20}kg/ha, N_0K_{40}kg/ha, N_0K_{80}kg/ha, $N_{40}K_0$kg/ha, $N_{40}K_{20}$kg/ha, $N_{40}K_{40}$kg/ha, $N_{40}K_{80}$kg/ha, $N_{80}K_0$kg/ha, $N_{80}K_{20}$kg/ha, $N_{80}K_{40}$kg/ha, $N_{80}K_{80}$kg/ha, $N_{120}K_0$kg/ha, $N_{120}K_{20}$kg/ha, $N_{120}K_{40}$kg/ha and $N_{120}K_{80}$kg/ha. The soils were mixed with various levels of nutrients using urea to supply nitrogen and muriate of potash as source of potassium at 4 weeks after planting (WAP) by using the side placement method.

The size of each plot measured 5m x 4m (20m^2) with spacing of 1m between plots, and 1.5m between replicates, giving a plant population of 20 plants per plot (10,000 plants/ha). There were, thus, a total of 48 plots (16 x 3). The experimental area was 1701m^2 (0.17 ha). Weeding was carried out manually by hoeing at 3 WAP and repeated at 8 WAP for the second operation. Subsequent weed control was by rouging at 14 and 20 weeks after planting (WAP). Data collection was carried out at 2, 4, 6, 8 and 10 months after planting (MAP). Four plants from the centre were randomly selected per plot, tagged and sampled as necessary. Assessments of the following parameters were done:

➢ **Plant Height:**

A tape rule was used to measure the height of plants from the soil surface to the top on the main branch. The stem girth was determined by using a string around the plant at the first internode and later spread on a ruler. The measurements were expressed in cm.

➢ **Fresh Tuber Weight:**

Four mature tagged cassava plants at the centre rows (net plot) were selected from each plot for harvesting and weighing.

❖ **Data Analysis:**

All data of parameters were subjected to the appropriate analysis of variance (ANOVA) and Correlation procedures as described by Steel and Torrie, 1980.

RESULTS AND DISCUSSION:

❖ **Soil Analysis Result:**

The texture of the soils varied from sand to loamy sand. Soil samples for N0K80, N_{40}K0, N_{40}K, $N_{40}K_{60}$ $N_{80}K_{60}$ and $N_{80}K_{80}$ were found to be sandy at the top soil while N_0K_0, N_0K_{20}, N_0K_{60}, $N_{80}K_{20}$, $N_{120}K_0$, $N_{120}K_{20}$, $N_{120}K_{60}$ and $N_{120}K_{80}$ were found to be loamy sandy texture (Table 1).

Total N content of the soils at all the location ranged from 0.03% in N_0K_0 to 0.17% in soil for N_0K_0 and $N_{120}K_0$ (Table 2) at the surface using a critical level of

0.15% (FDALR, 2004). The soils at the location had a moderate total nitrogen contents.

Available phosphorus for the locations ranged from 3.23mg/kg at the surface (Table 2). This ranged from low to high. Most of the soils of the various location treatments were low in phosphorus with the exception of soils of N_0K_{60} that increased in phosphorus content. N_0K_{60} had high phosphorus content while N_0K_0 where low in available phosphorus when compared to the established critical value of 17mg/kg (Agboola, A. A., & Corey, R. B. 1993).

Table 1: Physical Properties of Soils (0 - 15cm) after 1st cropping

Sample Location	Soil Properties Sand	Silt	Clay	Textural Class
	gm/kg			
ABRAKA (Forest zone)				
N_0K_0	888.0	81.0	31.0	LS
N_0K_{20}	888.0	81.0	31.0	LS
N_0K_{60}	864.0	90.0	46.0	LS
N_0K_{80}	908.0	71.0	21.0	S
$N_{40}K_0$	908.0	71.0	21.0	S
$N_{40}K_{20}$	918.0	61.0	21.0	S
$N_{40}K_{60}$	913.0	66.0	21.0	S
$N_{40}K_{80}$	888.0	81.0	31.0	LS
$N_{80}K_0$	918.0	61.0	21.0	S
$N_{80}K_{20}$	888.0	81.0	31.0	LS
$N_{80}K_{60}$	908.0	71.0	21.0	S
$N_{80}K_{80}$	908.0	71.0	21.0	S
$N_{120}K_0$	874.0	80.0	46.0	LS
$N_{120}K_{20}$	888.0	81.0	31.0	LS
$N_{120}K_{60}$	898.0	71.0	31.0	LS
$N_{120}K_{80}$	888.0	81.0	31.0	LS

S = Sand; LS = Loamy Sa

Table 2: Chemical Properties of Soils (0 -15cm) after 1st cropping and application of N and K

Treatments	pH H_20	EC	Total N	Organic Carbon	Av Available P	Na (Exchangeable)	K	Mg	Ca^2	Al^{3+}	H+	ECEC	OM	Zn	Pb	Fe	C	Mn
		%			mg/kg	cmo/kg						%	mg/kg					
ABRAKA (Forest zone)																		
N0K0	5.7	13.2	0.03	0.58	3.23	0.27	0.10	0.32	1.52	T	0.4	2.60	10.0	83.70	1.11	84.8	8.03	0.31
N0K20	5.7	4.42	0.07	0.93	7.43	0.23	0.10	0.48	1.92	T	0.4	3.12	16.1	198.7	1.14	86.2	9.50	0.34
N0K60	4.7	4.32	0.10	1.22	25.3	0.24	0.06	0.32	1.36	T	1.5	3.78	21.0	115.7	1.29	87.1	9.37	0.31
N0K80	4.0	9.64	0.10	1.06	9.03	0.19	0.07	0.56	1.68	T	1.8	4.80	18.3	177.8	1.14	85.6	24.5	0.36
N40K0	5.1	5.90	0.13	1.41	6.58	0.26	0.09	0.80	1.44	T	1.9	3.59	24.3	245.8	1.22	85.8	8.37	0.40
N40K20	5.8	5.71	0.15	1.60	8.44	0.32	0.14	1.52	2.16	T	0.4	4.54	27.7	78.43	1.07	85.2	6.69	0.27
N40K60	5.7	7.52	0.10	1.28	9.70	0.28	0.10	1.04	1.44	T	0.4	3.26	22.1	141.2	1.02	83.5	8.03	0.28
N40K80	5.5	3.01	0.12	1.31	9.76	0.16	0.07	0.96	1.68	T	0.4	3.27	22.7	136.0	1.17	84.6	7.83	0.32
N80K0	5.6	4.89	0.14	1.54	9.84	0.22	0.06	1.04	1.12	T	0.4	2.83	26.6	99.37	1.12	84.8	7.23	0.28
N80K20	5.8	4.01	0.16	1.63	9.43	0.23	0.08	1.04	1.52	T	0.3	3.16	28.2	141.8	1.28	85.7	8.16	0.35
N80K60	4.7	4.46	0.17	1.86	13.1	0.23	0.09	0.64	1.68	T	1.5	4.44	32.1	156.9	1.50	86.8	9.17	0.31
N80K80	5.5	5.39	0.11	1.38	14.2	0.23	0.07	1.52	1.60	T	0.4	3.81	23.8	319.1	1.15	84.3	6.29	0.21
N120K0	5.8	5.55	0.17	2.78	10.5	0.22	0.12	0.08	3.52	T	0.3	4.22	48.1	277.2	1.34	83.6	6.42	0.24
N120K20	4.8	5.96	0.15	1.70	14.0	0.23	0.08	1.44	2.16	T	1.5	5.40	29.3	219.7	1.14	83.9	7.96	0.28
N120K60	5.6	50.7	0.14	1.66	11.3	0.26	0.09	1.04	1.68	T	0.4	3.47	28.8	214.4	1.03	82.3	7.29	0.27
N120K80	6.3	4.20	0.08	0.96	9.92	0.24	0.07	0.40	2.40	T	0.2	3.31	16.7	152.7	1.01	82.7	7.90	0.28

Av. P = Available phosphorus
EC = Electrical conductivity
ECEC= Effective cation exchange capacity
OM = Organic matter
T = Trace

❖ **Plant Height:**

The effect of N fertilizer application on plant height of cassava at Abraka soils are shown in Table 3. The highest mean plant height of 213.2cm was obtained from120kg/ha at 10th MAP. This was not significantly different from the mean plant heights obtained from the other treatments while the effect of K fertilizer application on plant height of 207.0cm obtained from 80kgK/ha was highest and not significant at 4, 6, 8 and 10 MAP. The application of120kg/N and 80kg/K gave the highest mean plant height when compared to other treatment combinations. N and K applications generally resulted in increased plant height even though this trend was not consistent during some of the months of planting. Nitrogen has been reported to favour plan height of cassava especially at the initial stage of growth in respect to vegetative character and tuber yield and this is in consonance with previous findings of Utomakili and Enobakhare (Utomakili, V. B., & Enobakhare, D. A. 1995) and Agba *et al.,* (Agba, O. A. *et al.,* 2005).

Table 3: Effect of Nitrogen and Potassium fertilizer on mean plant (cm) of cassava (TME 419) varieties at Abraka

Treatments/variety Nitrogen (Kg/ha)	Potassium (kg/ha) (cm²) 0	20	40	80	Mean
2MAP					
0	13.5	17.7	15.7	14.3	15.3b
40	17.3	18.3	21.7	16.7	18.5ab
80	17.3	21.2	17.2	22.7	19.6a
120	18.7	19.5	17.0	17.2	18.1ab
Mean	16.7ns	19.2	18.0	17.7	
LSD(N=3.8)					
4MAP					
0	40.8	45.7	43.7	27.5	39.4ns
40	46.8	71.8	61.0	54.8	58.6
80	49.0	66.0	69.2	58.0	60.5
120	42.8	57.7	44.5	65.1	52.5
Mean	44.9ns	60.3	54.6	51.4	
6MAP					
0	84.0	45.3	109.7	72.3	88.6b
40	108.0	122.3	139.7	123.2	123.3a
80	106.0	123.8	137.5	126.3	123.4a
120	111.8	145.2	124.2	147.0	132.0a
Mean LDS (N=34.2)	102.5ns	119.9	127.8	117.2	
8MAP					
0	127.7	174.0	151.0	119.3	143.0b
40	147.3	173.0	196.0	163.3	169.9ab
80	145.3	171.0	187.8	205.5	177.2ab
120	163.3	187.3	171.3	200.2	180.5a
Mean	145.9ns	176.1	176.5	172.1	
LSD(N=36.60)					
10 MAP					
0	147.7	193.0	178.3	132.0	163.0b
40	171.0	198.2	218.5	218.8	201.6ab
80	173.2	208.8	211.7	244.8	209.6a
120	180.8	227.8	211.7	232.5	213.2a
Mean LSD(N=40.5)	145.9ns	176.1	176.5	172.1	

Figures in the column and rows followed by the same letter are not significantly different at 5% level of probability for each location.
NS = Not significant.

❖ **Fresh Tuber Weight:**

The highest fresh weight of 20.5t/ha were obtained from the application of 120kgN/ha +20kgK/ha. The application of N resulted in different yields among the treatments. A fresh tuber weight of 16.37t/ha was obtained from the application of 20kg/ha. The application of K resulted in significant difference among the treatments. The interaction between N and K had significant effect on fresh tuber weight in Delta State (Table 4). The application of 120kgN/ha +20 gave the best cassava tuber weight. This suggests that high level of N with a corresponding relatively high level of K interacted effectively, to enhance cassava performance. According to Ayoola (2006), K in the soil is readily released for cassava plant. Odeline (Odedina, S. A. 2005) found out that 60kgK/ha and 120KgN/ha gave highest cassava yield among the rates he considered in his study. He also observed that N requirement of cassava can only reduce when P is applied in adequate amount. The influence of higher potassium fertilization in increasing cassava yield was earlier reported by Enwezor *et al.,* (Enwezor, W. U. *et al.*, 1989) and Odiete *et al.,* (Odiete, I. *et al.*, 2006) in soils with medium or low K status.

Table 4: Effect of nitrogen and potassium fertilizer on cassava fresh tuber weight (t/ha)

Treatments/variety Nitrogen (Kg/ha)	Potassium (kg/ha) 0	20	40	80	Mean
	⟶		t/ha	⟵	
TME419		ABRAKA			
Fresh tuber weigh					
0	10.0	19.2	16.3	10,07	14.05a
40	12.1	13.6	18.8	15.5	15.03ab
80	10.4	12.1	12.7	18.8	13.52ab
120	10.5	20.5	12.7	19.1	15.7a
Mean	10.78b	16.37a	15.13a	16.03a	
LSD (N=1.69, K=1.69)					

Figures in the column and rows followed by the same letter are not significantly different at 5% level of probability for each location. NS = Not significant.

❖ **Hydrogen Cyanide (HCN) Content of Tubers:**

The highest HCN content of 22.5mg/kg was obtained from the application of 80kgN/ha + 20kgK/ha, while the lowest value were 9.3mg/kg for the applications of 40kgN/ha + 80kgK/ha. However, higher application rates of N reduced HCN contents. In the same vein, HCN content was raised from 16.0mg/kg in the control to 22.5mg/kg when K was applied at 80kg/ha.

The interaction between N and K fertilizers increased HCN level at lower application rates but the reverse was the case at higher rates.

High levels of nitrogen in the soil tends to increase the level of glucoside in cassava plant within a particular cultivar, the exact level glucoside can vary slightly, depending on environmental factors (IITA International Institute for Tropical Agriculture. 1990).

Table 4: Effect of nitrogen and potassium fertilizer on level of hydrogen cyanide (HCN) content in tubers.

Treatments/variety Nitrogen (Kg/ha)	Potassium (kg/ha) 0	20	40	80	Mean
	⟶		Mg/kg	⟵	
TME 419					
0	16.0	23.5	16.9	16.3	18.2a
40	20.0	16.1	16.4	9.30	15.5b
80	20.2	22.5	15.0	14.9	18.2a
120	18.0	22.1	17.1	19.9	19.3a
Mean	18.6b	21.1a	16.4 c	15.1c	
LSD (N=1.6)(K=1.6)					

Figures in the column and rows followed by the same letter are not significantly different at 5% level of probability for each location. NS = Not significant.

CONCLUSION:

The determination of the effects of nitrogen and potassium status of selected soils and their effects on the growth, yield and cyanide content of cassava (*Manihot esculenta* Crantz) variety was the principal objective of this study. The study was conducted in Delta State. Soil analysis to determine the levels of plant nutrients in the soils was carried out. The determination of the effects of nitrogen and potassium status on the growth, yield and cyanide content was determined. However, the application of 120kgN/ha +20 (20.5) gave the best yield while the highest HCN content of 22.5mg/kg was obtained from the application of 80kgN/ha + 20kgK/ha in Delta State, Nigeria.

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