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Full Length Research Paper

Root growth and NPK status of cassava as influenced by oil palm bunch ash

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Experiments were carried out at Omoku and Umudike in southeast Nigeria to study effect of oil palm bunch ash (OBA) on number, length, diameter of roots, dry root yield and leaf N, P and K content of bitter and sweet cassava (*Manihot esculenta* Grantz). The 0.00, 1.25, 2.50, 3.75, 5.00 t/ha OBA and 600 kg/ha NPKF [15:15:15) fertilizer were applied on soil to cassava and root growth parameters were determined at 3, 6, 9, and 12 months after planting (MAP). Root dry weight and leaf N, P and K were determined at 12 MAP. OBA treatments and NPKF increased root length, root diameter, number of roots, root weight and leaf N, P and K concentrations significantly (P = 0.05). The 2.50, 3.75, 5.00 t/ha OBA and NPKF gave similar values of root diameter. The 2.50 t/ha OBA gave the highest mean root yield and tuber yield of sweet cassava. The 2.50 and 3.75 t/ha OBA increased tuber yield than NPKF by 83%. Application of 2.50 t/ha OBA is recommended.

Key words: Cassava, oil palm bunch, fertilizer, yield.

INTRODUCTION

Cassava root products are energy rich foods widely consumed in sub-Sahara Africa by about 40% of the population. In Congo, Gabon, Mozambique and Zaire, people derive 1000 calories a day from cassava tubers which is about 50% of food intake. Aside from increasing hectarage under cassava, a major approach to increasing cassava output is to improve soil fertility by application of organic manures and chemical fertilizers. Cassava is known to respond positively to soil fertility and adequate fertilizer. It is estimated that cassava removes 55 kg/ha N, 132 kg/ha P and 112 kg/ha K (Howeler, 1991).

However, farmers rarely use chemical fertilizers on cassava because of scarcity and cost. Also improper use of common NPK fertilizer was found to reduce tuber yield of late planted cassava (Agbaje and Akinlosotu, 2004). In recent years, there is more dependence on use of local sources, cheap organic sources of nutrients for cultivation of cassava and other crops. The above reasons necessitated research on increasing effectiveness of organic manures and wastes for enhanced productivity of cassava. Also research and development activities on cassava are not commensurate with increasing importance as Industrial and food crops.

Okigbo (1989) found that crop wastes such as those of legumes, cassava, rice and maize increased yield of cassava when used as mulch. Enegi et al. (1997) observed that farm yard manure combined with NPK fertilizer increased yield of cassava relative to manure or fertilizer alone. Le (1998) asserted from his study on bio-digester effluent versus pig and cattle manures that biodigester effluent produced higher biomass, yield and protein content of cassava than raw manure or no manure.

Published works on effect of oil palm bunch ash (OBA) on yield and nutrient content of cassava are limited. OBA is a waste product of oil palm fruit processing which re-

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Table 1. Data of analysis of soil and oil palm bunch ash (OBA).

Property	Omoku	Umudike	OBA%
pH (1: 2.5 H_2O)	4.60	4.62	-
Org. C (%)	1.08	1.35	-
Total N (%)	0.053	0.013	1.15
Available P mg/kg	16.0	16.2	1.90
Exch. K (cmol/kg)	0.16	0.19	2.17
Exch. Ca (cmol/kg)	0.26	2.32	0.85
Exch. Mg (cmol/kg)	0.18	1.30	1.80
Sand (%)	74.0	73.0	-
Silt (%)	10.0	16.9	-
Clay (%)	16.0	10.1	-

sults from incineration of palm bunch residues after fruit extraction. About 850 kg/ha bunch residue is generated annually in Nigeria and it contains substantial N and K which are essential for optimal tuber yield of cassava. Ojeniyi et al. (2006) found that OBA at 4 t/ha increased significantly yield of maize and its leaf N, P, K, Ca and Mg content. Hence the aim of this study was to determine the response of tuber growth and yield components of cassava and its NPK status to applications of OBA and NPK fertilizer in southeast Nigeria.

MATERIALS AND METHODS

Field experiment

Experiments were conducted using two types of cassava in 2003/ 2004 at Omoku (5°>20' N, 6° 40' E) and Umudike (5° 29' N, 7° 32' S) in the rainforest zone of southeast Nigeria. The soil at Omoku is typic palendult derived from alluvial plain, and the top soil is sandy loam. The soil at Umudike is typic palendult derived from coastal plain sand, and the top soil is loamy sand. The land at the two locations had been under rotational cropping for at least 12 years.

Experiments were laid out as split plot fitted into a randomised complete block design (RCBD) with four replications. Two cassava varieties NR8082 (bitter) and Nwabibi (sweet) served as the main plots, while five levels of palm bunch as (OBA) at 0.00, 1.25, 2.50, 3.75 and 5.00 t/ha and NPK 15:15:15: fertilizer at 600 kg/ha served as subplots. Plot size was 48 m^2. The land was mowed, ploughed, harrowed and ridged. Cassava cuttings (30 cm long) were planted on the creep of ridges at 1 by 1 m. Planting at Omoku was done in April 2003 while that of Umudike was July 2003. The OBA and fertilizers were manually applied at 2 months after planting. Weeding was done at 2, 5 and 10 months after planting.

Soil and OBA analysis

Prior to land preparation, surface (0 to 15 cm) soil samples were collected using steel core over each experimental site, bulked air-dried and sieved (2 mm) for routine analysis (Carter, 1993). The OBA was also analysed. Soil pH was measured with a glass electrode in a 1:2 soil water suspension and particle size was determined by hydrometer method. Organic matter was determined by dichromate oxidation method and total N by micro-kyeldahl approach. Available P was determined using Bray- 1 approach. After ammonium acetate extraction, K was determined using flame photometer, and Ca and Mg by atomic absorption spectrophotometer.

Leaf analysis

At harvest (12 MAP) leaf samples were collected per plot, air–dried and ground. Samples were air - dried for 48 h 65°C in oven and ground to pass 0.5 mm pore size. The samples were digested using kyeldahl method, P by molybdenum blue colorimetric and K by flame photometer.

Root data

The mean root diameter, length and number of roots per plant were measured at 3, 6 and 9 months after planting (MAP), Two plants were randomly and destructively sampled per plot for measurements. At harvest (12 MAP), a net plot was created per plot. Roots harvested were oven-dried at 65°C for 48 h and root weights taken.

Statistical analysis

Data were subjected to analysis of variance and means compared by least significant difference at p = 0.05.

RESULTS AND DISCUSSION

The soils at Omoku and Umudike were acidic, low in organic matter, N, K and Mg (Table 1). Exchangeable Ca was also low at Omoku and marginal at Umudike. The critical levels of pH and nutrients set for cassava were pH 5.2-7.0, 0.2% N, 7.3 mg/kg available P, 0.14-1.20 cmol/ kg exchangeable K, and 3-8 C mol/kg exchangeable Mg (Howeler, 1991). The critical levels of organic matter for crop production in Nigeria ecological zones were 3.0%, and the value for exchangeable Ca was 2.2 cmol/kg (Akinrinde and Obigbesan, 2000). Analysis of OBA indicated it had considerable percentages of N, P, K, Ca and Mg (Table 1). Hence nutrients released from OBA would contribute to improving nutrient availability to cassava on the infertile soils.

The OBA and NPKF increased number of roots relative to control at 3, 6, 9 and 12 MAP at Omoku (Table 2) and Umudike (Table 3). The increases by using all treatments except 1.25 t/ha OBA relative to the control was significant. The 2.50 t/ha OBA tended to give the highest value of number of roots of sweet cassava, while the 3.75 t/ha OBA gave the highest value for bitter cassava. The mean values of number of roots per plant and recorded for O, 1.25, 2.50, 3.75, 5.00 t/ha OBA and 600 kg/ha NPKF were 6.4, 9.2, 13.0, 12.6, 9.8 and 13.0, respecttively. Therefore 2.50 t/ha OBA ad NPK had similar and highest mean values of number of roots. Both treatments increased number of roots up to 103%. Number of roots increased with time between 3 and 9 MAP and it dropped between 9 and 12 MAP. This agrees with the observation of Ekanayake (1993) that on bulking several primary fibrous roots die and decay due to competition for avail-

Table 2. Effects of palm bunch ash (OBA) on number of roots per cassava plant at Omoku.

OBA t/ha	3MAP		6MAP		9MAP		12MAP	
	B	S	B	S	B	S	B	S
O	6.6	4.5	9.6	6.1	7.9	5.1	7.3	5.1
1.25	9.4	7.5	11.4	11.1	10.4	8.1	10.1	8.0
2.50	11.8	11.4	13.6	13.5	13.0	10.4	13.1`	11.1
3.75	12.9	7.3	15.3	9.8	13.5	8.5	13.1	8.5
5.00	8.8	8.6	10.9	11.0	10.0	9.1	9.5	8.8
60 kg/ha NPkF	15.1	10.5	16.1	11.9	13.6	8.6	13.4	8.5
LSD (0.05)	3.0	4.9	2.9	4.3	3.3	3.8	3.4	3.8

MAP = Month after planting; B = bitter cassava; S = sweet cassava.

Table 3. Effect of palm bunch ash (OBA) on number of roots per cassava plant at Umudike.

OBA (t/ha)	3MAP		6MAP		9MAP		12MAP	
	B	S	B	S	B	S	B	S
O	8.2	6.4	10.3	9.7	7.5	6.0	7.3	5.9
1.25	9.5	7.7	12.7	10.0	10.1	8.5	10.1	8.5
2.50	12.5	11.5	16.3	15.4	15.3	13.0	15.3	12.8
3.75	14.1	10.6	18.5	12.5	17.2	11.3	17.2	11.3
5.00	8.3	9.3	11.4	12.5	11.0	10.5	10.4	10.4
600 kg/ha NPKF	15.5	10.0	20.7	13.1	17.7	12.9	17.5	12.5
LSD(0.05)	1.17	1.12	2.16	1.59	4.81	1.21	2.89	1.32

MAP = Month after planting; B = bitter cassava; S = sweet cassava.

Table 4. Effect of palm bunch ash (OBA) on number on cassava root diameter at Omoku (cm).

OBA (t/ha)	3MAP		6MAP		9MAP		12MAP	
	B	S	B	S	B	S	B	S
O	0.98	0.58	2.62	2.30	2.78	2.77	3.19	3.15
1.25	1.15	0.84	2.93	2.83	3.20	3.21	3.66	3.73
2.50	1.36	1.26	3.29	3.42	3.71	4.00	4.08	4.53
3.75	1.83	1.10	3.63	3.02	4.29	3.46	4.87	3.96
5.00	1.58	0.94	3.16	3.16	3.63	3.29	3.88	3.68
600 kg/ha NPKF	1.37	1.04	3.03	3.08	3.41	3.41	4.13	3.99
LSD(0.05)	0.29	0.12	0.29	0.36	0.29	0.34	0.34	0.31

MAP = Month after planting; B = bitter cassava; S = sweet cassava.

able carbohydrate tours located from the source. Bitter cassava produced more number of roots than sweet cassava.

Cassava roots diameter was significantly (p=0.05) increased by OBA and NPKF treatments irrespective of month of determination, location and variety (Tables 4 and 5). The 2.50 t/ha OBA gave the highest values for sweet cassava, while the 3.75 t/ha OBA gave the highest values for bitter cassava at both locations. Similar observation was found in respect of number of roots. The mean root diameters for 0, 1.25, 2.50, 3.75, 5.00 t/ha OBA and 600 kg/ha NPKF were 3.26, 3.99, 4.75, 4.86, 4.31, and 4.35 cm respectively. The 2.50 and 3.75 t/ha OBA had the highest and similar values. Bitter cassava had higher root diameter than sweet cassava. The linear pattern of cassava root diameter expanding with time in line with the finding of Ekanayake (1993) who observed that the higher the translocation of carbohydrate to the roots the higher the cambial activity causing it to enlarge in size.

Root length of sweet cassava was increased by OBA and NPKF treatments at 3, 6, 9, and 12 MAP at Omoku

Table 5. Effect of palm bunch ash (OBA) on number on cassava root diameter at Umudike (cm).

OBA (t/ha)	3MAP		6MAP		9MAP		12MAP	
	B	S	B	S	B	S	B	S
O	1.00	0.84	2.58	2.57	3.08	3.01	3.36	3.34
1.25	1.26	1.12	2.76	2.79	3.73	3.57	4.46	4.09
2.50	1.25	1.77	3.53	3.65	3.97	4.67	5.08	5.27
3.75	2.05	1.37	3.66	3.21	5.08	3.90	6.04	4.53
5.00	1.04	1.14	3.49	2.84	4.29	3.64	5.28	4.40
600 kg/ha NPKF	1.15	1.43	3.53	3.10	4.14	3.89	5.38	4.64
LSD(0.05)	0.12	0.23	0.58	0.50	0.80	0.50	0.43	0.40

MAP = Month after planting; B = bitter cassava; S = sweet cassava.

Table 6. Effect of palm bunch ash (OBA) on cassava root length at Omoku (cm).

OBA (t/ha)	3MAP		6MAP		9MAP	
	B	S	B	S	B	S
O	25.9	25.2	34.5	33.8	33.2	39.3
1.25	25.6	29.9	37.1	37.7	35.1	43.2
2.50	24.9	36.7	29.7	44.4	27.9	51.6
3.75	24.9	40.5	34.6	51.3	33.0	59.0
5.00	23.9	47.0	32.5	63.1	29.6	72.4
600 kg/ha NPKF	26.8	35.8	32.9	49.9	30.5	57.1
LSD(0.05)	1.55	6.76	4.04	11.78	2.13	7.72

MAP = Month after planting; B = bitter cassava; S = sweet cassava.

Table 7. Effects of palm bunch ash (OBA) on cassava root length at Umudike (cm).

OBA (t/ha)	3MAP		6MAP		9MAP	
	B	S	B	S	B	S
O	25.8	28.5	31.3	34.3	29.5	40.5
1.25	26.1	36.1	38.3	41.7	36.9	45.4
2.50	25.5	39.3	31.9	45.5	30.4	52.6
3.75	24.4	45.3	35.4	55.7	32.5	64.2
5.00	25.5	50.9	33.2	69.2	30.5	73.1
600 kg/ha NPKF	25.8	41.7	33.5	58.3	33.6	64.2
LSD(0.05)	1.20	1.55	1.77	2.98	8.80	2.78

MAP = Month after planting; B = bitter cassava; S = sweet cassava.

(Table 6) and Umudike (Table 7). The increases were significant. However, the treatments did not increase root length of bitter cassava significantly. There were no increases in root length. Unlike, in sweet cassava, root length increased with level of OBA at both locations. The mean values of root length at Omoku for 0, 1.25, 2.50, 3.75 and 5.00 t/ha OBA and NPKF were 34.0, 34.6, 37.4, 44.3, 48.4, and 42.2 cm respectively. The values for Umudike were 32.8, 38.3, 37.4, 44.5, 49.4, and 46.7 cm. The 5.00 t/ha OBA increased root length than NPK at 9 MAP root length of bitter cassava started to reduce due to high rate of bulking. Practically the sweet cassava produced longer root than bitter Cassava. These findings agree with those of Maduakor (1991) and Ekanayake (1993) who reported that root length of cassava harvested at 80-90 days after planting and later fall. The fall was attributed to rapid storage root bulking.

Table 8 shows that dry root weight was increased by

Table 8. Effects of palm bunch ash (OBA) on dry root weight of bitter (B) and sweet (S) cassava at Omoku and Umudike t/ha

OBA (t/ha)	Omoku		Umudike	
	B	S	B	S
0	4.73	4.11	5.92	4.99
1.25	5.32	4.99	6.63	5.44
2.50	6.55	6.79	7.34	8.64
3.75	7.45	5.63	8.02	7.63
5.00	6.14	4.78	6.74	6.42
600 kg/ha NPKF	6.14	5.05	6.63	6.72
LSD(0.05)	0.85	0.64	1.13	1.00

Table 9. Effect of palm bunch ash (OBA) on leaf nutrient status of cassava at Omoku (O) and Umudike (U).

OBA (t/ha)	N (%)		P (%)		K (%)	
	O	U	O	U	O	U
Bitter cassava						
0	0.25	0.17	0.14	0.17	0.85	1.03
1.25	0.32	0.24	0.25	0.33	0.95	1.09
2.50	0.37	0.32	0.32	0.37	1.14	1.14
3.75	0.47	0.45	0.40	0.41	1.14	1.28
5.00	0.62	0.53	0.45	0.46	1.31	1.55
600 kg/ha NPKF	0.42	0.42	0.39	0.43	1.23	1.48
LSD (0.05)	0.13	0.09	0.14	0.08	0.13	0.15
Sweet cassava						
0	0.27	0.13	0.14	0.15	0.98	1.01
1.25	0.32	0.23	0.19	0.18	0.01	1.07
2.50	0.33	0.27	0.22	0.23	1.15	1.16
3.75	0.44	0.33	0.27	0.28	1.24	1.31
5.00	0.47	0.43	0.33	0.30	1.36	1.46
600kg/ha NPKF	0.40	0.35	0.30	0.40	1.18	1.44
LSD (0.05)	0.10	0.10	0.05	0.07	0.19	0.18

OBA treatments and NPK. The increases were significant except in case of 1.25 t/ha OBA. The 2.50 and 3.75 t/ha OBA gave the highest values of root weight for sweet and bitter cassava respectively. Since the values recorded for the two treatments were similar, application of 2.50 t/ha OBA is recommended. Considering mean yield across variety and location, the values for 0, 1.25, 2.50, 3.75 and 5.00 t/ha OBA and NPK were 4.9, 4.9, 7.1, 7.2, 6.0 and 6.1 t/ha respectively. Relative to the control, 1.25, 2.50, 3.75 and 5.00 t/ha OBA and NPKF increased yield by 0, 44, 46, 22 and 24% respectively. Therefore the 2.5 t/ha OBA is optimum. The 2.5 and 3.75 t/ha OBA increased tuber yield than NPKF by about 83%.

The mean values of leaf N, P and K concentrations are presented in Table 9. Irrespective of location, leaf N, P and K increased with level of OBA. Therefore it is confirmed that OBA was an effective source of these nutrients. The 5.00 t/ha OBA increased these nutrients than NPKF. The increases due to OBA were significant especially when OBA was applied at 2.5 t/ha and above.

Because 2.5 t/ha gave optimum yield of cassava and the highest yield of sweet cassava, leaf nutrient contents for the treatment are considered as adequate and critical. These nutrient levels are 0.27 - 0.37% N, 0.22 – 0.37% P and 1.14% K. The finding that 5.00 t/ha OBA and NPKF reduced yield compared to 2.50 and 3.75 t/ha OBA could be due excess supply of N, P and K (Table 9). Excess K reduces uptake of Mg which is known to enhance tuber yield of cassava (CIAT, 1985). Also excess N and P due to their supply by 5.0 t/ha OBA and NPKF might have enhanced soil acidity and reduced uptake of Ca (by neutralization). Availability of Ca also enhances yield of cassava (CIAT, 1985). Compared with N, P, K and Mg, OBA had less concentration of Ca (Table 1). Weite et al. (1998) reported root yield reduction of 41% due to high N applications. High N stimulated production of N compounds such as protein and HCN which might have reduced root starch content.

This work confirms that oil palm bunch ash (OBA) increased availability and uptake of N, P, and K by cassava and this led to significant increases in cassava root length, diameter and yield. In Asia, Latin, American, Nigeria and other African countries in the sub-Sahara, significant positive responses of cassava to N, P, and K fertilizers have been recorded (Agbede and Akinlosotu, 2004; Nair et al., 1988: FAO, 1980). The positive effect of OBA contributes to elevate soil nutrients content and other nutrients such as Ca and Mg contained in OBA.

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