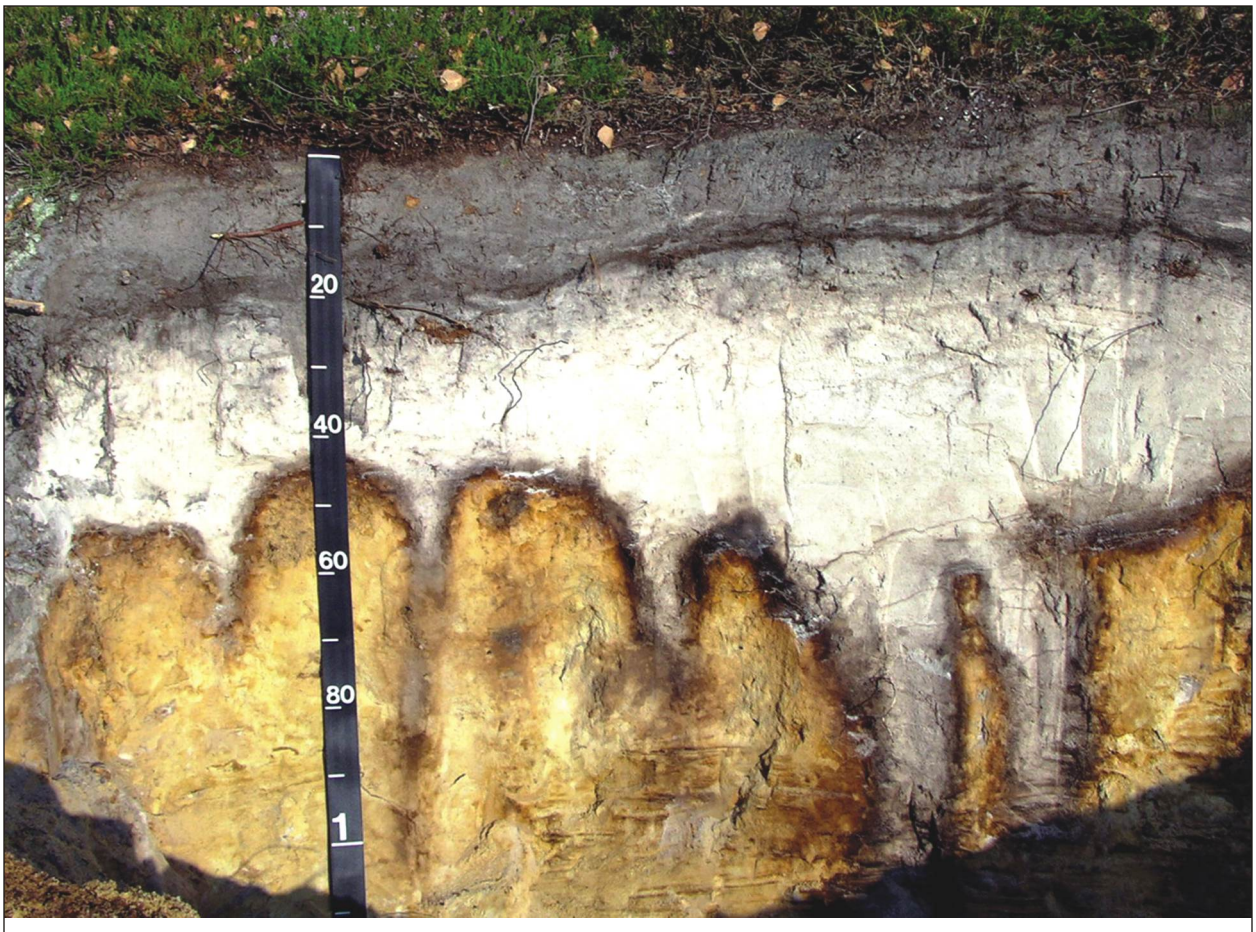

International Journal of Soil Science

ISSN 1816-4978

Academic Journals Inc.

www.academicjournals.com

International Journal of Soil Science 2 (2): 148-153, 2007
ISSN 1816-4978

Comparative Effect of Cocoa Pod Husk Ash and NPK Fertilizer on Soil and Root Nutrient Content and Growth of Kola Seedling

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Abstract: Screen house experiment was conducted to study effectiveness of Cocoa Pod Husk Ash (CPHA) as source of nutrients for kola (*Cola nitida)* seedlings. Six levels of CPHA namely: 0. 2, 4, 6, 8 and 10, t ha^{-1} and 200 kg ha^{-1} NPK (15-15-15) fertilizer (NPKF) were applied to seedling at Akure and Ibadan Southwest Nigeria. The CPHA treatments and NPKF increased significantly the seedling height and number of leaves. The 2, 4 and 6 t ha^{-1} CPHA had higher values of the growth parameters than NPKF. Application of CPHA increased soil organic matter, available P and exchangeable K, Ca and Mg. Compared with NPKF, application of CPHA increased significantly root N, P, K, Ca and Mg concentrations which increased with level of CPHA. Compared with NPKF, CPHA at 2, 4, 6, 8 and 10 t ha^{-1} gave higher values of root P and Ca uptake. The 4 and 6 t ha^{-1} CPHA gave highest values of seedlings height and number of leaves respectively and higher root Ca uptake.

Key words: Cocoa pod husk ash, kola, seedlings, exchangeable, number of leaves, root Ca uptake

INTRODUCTION

Kola (*Kola nitida)* nuts are source of essential oils and alkaloids which have utilization in the preparation of beverages and pharmaceutical product and for flavouring in confectionary industry. Kola nut is also used as masticatory for its stimulating effect. The bark of kola tree has medical value, its roots are used as chewing sticks and the wood is used in carving. Because of its economic importance, there is need to plant high yielding early maturing kola plants which are now available. The young plants should be raised in nurseries using fertile top soil rich in nutrients and organic matter. However, it is often difficult to obtain adequate suitable top soil due to deforestation. Egbe *et al*. (1989) observed that kola soils in Nigeria had low exchangeable K, N and P. Widespread deficiency of B and Cu was also reported (Egbe and Olaniran, 1980). However the use of chemical fertilizers in kola production is hindered by its scarcity, high cost, incomplete nutrient supply and possible enhancement of soil acidity in case of N fertilizers. It was always found that N fertilizer depressed kola yield (Egbe *et al*., 1989).

There is need to study cheap, locally sourced agricultural wastes that could enhance balance crop nutrition, improve nutrient availability and serve as liming material to control soil acidity in kola production. Cocoa Pod Husk Ash (CPHA) is such a material (Odedina *et al*., 2003). An earlier study by Adu-Dapach *et al*. (1994) in Ghana showed that CPHA was an effective source of K for increasing grain yield of maize. In Nigeria, Odedina *et al*. (2003) found that CPHA had higher N, K and Ca concentrations than ashes of rice bran and wood. They also observed that CPHA application increased soil macronutrient contents and yield of tomato. Nigeria produces annually about 8,000,000 tonnes

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of Cocoa Pod Husk (CPH), which are left to waste. By this it was estimated that 64000-94000 tonnes of nutrients like K, Ca and P and between 6000-9000 tonnes of N are lost annually (Egunjobi, 1975). The study by Egunjobi (1975) indicates that CPH could be used as fertilizer and nematicide. It increased maize yield by 124%. Omoti *et al*. (1991) found that forms of CPH compared favourably with NPK fertilizers as to their effect on maize growth. Greenwood and Burton (1965) cited by Egunjobi (1975) suggested the use of CPH as fertilizer in order to solve its disposal problem. The study being reported was carried out to study effect of cocoa pod husk ash on soil nutrient status, growth and root nutrient uptake of kola seedling.

MATERIALS AND METHODS

Screen House Experiment

A pot experiment was conducted at the screen house of Cocoa Research Institute of Nigeria Ibadan and Federal University of Technology Akure. The screen house at Ibadan was covered with glass at the side and had mean daily temperature of 31.1°C, while the screen house at Akure had nylon net at the side and roof and had mean daily temperature of 28°C. The experiments were conducted between 21st October 2003 and 21st April 2004.

Top soils collected from cocoa plots established in the two locations were used. A 4 L black pot with holes at the base was filled with 3 kg soil. CPHA at 0, 2, 4, 6, 8, 10 t ha^{-1} and 200 kg ha^{-1} NPK (15-15-15) fertilizer were applied to soil. These treatments are equivalent to 0, 3, 6, 9, 12 and 15 kg ash/pot and 0.3 g of NPK 15-5-15 fertilizer. The treatments were replicated three times using a randomized complete block design. There were four pots per treatment, given 84 pots in each experiment. Ash was mixed manually with top soil during filling of pots.

Improved variety of *Cola nitida* (2 leaves) seedlings collected from CRIN were potted in October 2003. Watering of seedlings was done every other day. Growth parameters determined six months after treatment application were plant height and number of leaves.

Statistical Analysis

Data were subjected to analysis of variance and the Duncan Multiple range test ($p>0.05$) was used to separate mean data on treatment basis.

RESULTS AND DISCUSSION

Table 1 and 2 show data on effect of CPHA and NPKF on seedling height at Ibadan and Akure Screen houses respectively. Compared with control CPHA at 2, 4, 6, 8 and 10 t ha^{-1} and NPKF increased kola seedling height significantly. At Ibadan and Akure 4 t ha^{-1} CPHA gave highest values of seedling height as shown by data collected monthly for six months. The treatment gave higher seedling height than NPKF at Ibadan. At Akure 2, 4 and 6 t ha^{-1} CPHA treatments had higher seedling heights compared with NPKF. The 8 and 10 t ha^{-1} CPHA treatments had less values of seedling height compared with 2, 4 and 6 t ha^{-1} CPHA.

Table 3 and 4 contain data on number of leaves of kola seedlings at Ibadan and Akure respectively. Compared with control, CPHA and NPKF increased number of leaves. At Ibadan 4 and 6 t ha^{-1} gave highest and similar values of number of leaves, while at Akure 6 t ha^{-1} had highest value for all months. At both locations 2, 4 and 6 t ha^{-1} CPHA treatments had highest values of number of leaves compared with NPKF.

Table 5 and 6 show data of soil analysis at Ibadan and Akure respectively. Soil pH and Ca increased with level of CPHA. A very strong correlation ($r = 1.00$) was recorded between level of CPHA and soil Ca at Ibadan and Akure were 1.00 and 0.70, respectively.

Table 1: Effect of Cocoa pod husk (CPHA) and NPK fertilizer (NPKF) on height of kola seedlings different months after application at Ibadan

	Months after application					
Treatments	1	2	3	4	5	6
0 t ha^{-1} CPHA	11.1^{d}	11.2^{d}	12.2^{d}	13.2^{d}	14.2^{d}	15.2^{d}
2 t ha^{-1} CPHA	24.3^{b}	25.3^{b}	26.4^{b}	27.3^{b}	28.3^{b}	29.4^{b}
4 t ha^{-1} CPHA	30.1^{a}	31.1^{a}	32.2^{a}	34.6^{a}	34.6^{a}	35.6^{a}
6 t ha^{-1} CPHA	23.8^{b}	23.8^{b}	24.9^{b}	26.0^{b}	27.0^{b}	28.0^{c}
8 t ha^{-1} CPHA	19.7^{c}	20.7^{c}	21.8^{c}	22.7^{c}	23.7^{c}	24.8^{c}
10 t ha^{-1} CPHA	22.8^{b}	23.8^{b}	24.8^{b}	25.8^{b}	26.8^{b}	27.8^{b}
NPKF 200 kg ha^{-1}	26.6^{a}	27.6^{a}	28.6^{a}	29.6^{a}	30.6^{a}	31.6^{a}

Values with different superscripts in a column are significantly different (p>0.05)

Table 2: Effect of Cocoa pod husk (CPHA) and NPK fertilizer (NPKF) on height of kola seedlings different months after application at Akure

	Months after application					
Treatments	1	2	3	4	5	6
0 t ha^{-1} CPHA	9.3^{e}	10.4^{e}	11.4^{e}	12.6^{e}	13.8^{e}	14.8^{e}
2 t ha^{-1} CPHA	28.0^{b}	29.6^{b}	30.1^{b}	31.0^{b}	32.0^{b}	33.0^{d}
4 t ha^{-1} CPHA	42.1^{a}	43.2^{a}	44.2^{a}	45.4^{a}	46.5^{a}	47.5^{a}
6 t ha^{-1} CPHA	30.3^{b}	30.4^{b}	31.4^{b}	33.7^{b}	34.8^{b}	35.8^{b}
8 t ha^{-1} CPHA	18.1^{d}	19.2^{d}	20.2^{d}	21.3^{d}	22.3^{d}	23.3^{c}
10 t ha^{-1} CPHA	18.1^{d}	19.2^{d}	20.2^{d}	21.3^{d}	22.3^{d}	23.3^{c}
NPKF 200 kg ha^{-1}	25.3^{e}	26.4^{e}	27.4^{e}	28.9^{e}	29.7^{c}	30.8^{b}

Values with different superscript in a column are significantly different (p>0.05)

Table 3: Effect of Cocoa pod husk ash (CPHA) and NPK fertilizer (NPKF) on number of leaves of kola seedlings at Ibadan

	Months after application					
Treatments	1	2	3	4	5	6
0 t ha^{-1} CPHA	2.3^{d}	2.6^{d}	2.8^{d}	3.0^{d}	4.0^{d}	4.8^{d}
2 t ha^{-1} CPHA	8.2^{b}	8.6^{b}	10.4^{b}	11.5^{c}	12.8^{b}	13.7^{b}
4 t ha^{-1} CPHA	3.2^{a}	9.6^{a}	11.4^{a}	12.6^{a}	13.8^{a}	14.7^{a}
6 t ha^{-1} CPHA	9.1^{a}	9.5^{a}	11.3^{a}	12.5^{a}	13.7^{a}	14.7^{a}
8 t ha^{-1} CPHA	4.0^{c}	4.4^{c}	6.2^{c}	7.0^{c}	8.0^{c}	9.0^{c}
10 t ha^{-1} CPHA	5.7^{c}	6.1^{c}	7.9^{c}	8.6^{c}	9.8^{c}	10.7^{c}
NPKF (200 kg ha^{-1})	7.0^{b}	7.4^{b}	9.2^{b}	10.0^{b}	11.0^{b}	12.0^{b}

Values with different superscripts in a column are significantly different (p>0.05)

Table 4: Effect of Cocoa pod ash (CPHA) and NPK fertilizer (NPKF) on number of leaves of kola seedlings at Akure

	Months after application					
Treatments	1	2	3	4	5	6
0 t ha^{-1} CPHA	8.3^{f}	9.0^{f}	10.2^{f}	11.2^{f}	12.2^{f}	13.2^{f}
2 t ha^{-1} CPHA	10.8^{d}	11.8^{d}	12.8^{d}	13.7^{d}	14.9^{d}	15.8^{d}
4 t ha^{-1} CPHA	12.5^{b}	13.6^{b}	14.5^{b}	15.4^{b}	16.5^{b}	17.5^{b}
6 t ha^{-1} CPHA	17.8^{a}	18.9^{a}	19.8^{a}	20.7^{a}	21.7^{a}	22.8^{a}
8 t ha^{-1} CPHA	11.5^{e}	12.6^{e}	13.5^{e}	15.6^{e}	15.6^{e}	16.5^{e}
10 t ha^{-1} CPHA	9.2^{e}	10.2^{e}	11.2^{e}	13.2^{e}	13.2^{e}	14.2^{e}
NPK (200 kg ha^{-1})	10.5^{d}	11.6^{d}	12.5^{d}	14.4^{d}	14.4^{d}	15.5^{d}

Values with different superscripts in a column are significantly different (p>0.05)

It is suggested that CPHA served as a liming material and reduced soil acidity. Also soil Mg increased with addition of CPHA up to 10 t ha^{-1} compared with 8 t ha^{-1}, soil K and Mg given by 10 t ha^{-1} CPHA reduced at Ibadan and soil K is also reduced at Akure. This could be due to competition for soil exchange sites and dominance of Ca^{++} at exchange sites at the high level of CPHA. However strong positive correlations were recorded between level of CPHA and exchangeable soil K at Ibadan (0.91) and Akure (0.65). The correlation coefficients between CPHA level and exchangeable soil Mg were 0.79 and 0.83 at Ibadan and Akure respectively. Application of CPHA at

Table 5: Effect of Cocoa pod husk ash (CPHA) and NPK fertilizer (NPKF) on soil chemical composition at Ibadan

Treatments	pH	OM (%)	N (%)	P Mg/kg	K Cmol/kg	Mg Cmol/kg	Ca Cmol/kg
0 t ha^{-1}	6.6^{e}	1.6^{d}	0.06^{a}	2.6^{e}	0.21^{e}	1.8^{e}	2.0^{f}
CPHA	7.4^{e}	2.2^{e}	0.008^{a}	2.9^{d}	0.43^{e}	2.2^{d}	2.0^{b}
2 t ha^{-1}	7.6^{e}	1.8^{e}	0.06^{a}	2.8^{d}	0.42^{e}	2.1^{d}	5.1^{d}
4t/CPHA	8.8^{b}	1.9^{b}	0.06^{a}	2.8^{d}	0.51^{b}	2.6^{d}	6.4^{a}
6 t ha^{-1} CPHA	8.9^{b}	2.0^{b}	0.06^{a}	6.1^{b}	0.61^{a}	4.6^{d}	6.7^{a}
8 t ha^{-1} CPHA	9.1^{a}	2.1^{a}	0.06^{a}	2.8^{d}	0.54^{b}	3.2^{b}	8.8^{e}
10 t ha^{-1} CPHA	6.9^{d}	1.8^{e}	0.08^{b}	3.5^{c}	0.30^{d}	3.2^{b}	3.0^{d}
NPKF							

Values with different superscripts in a column are significantly different ($p>0.05$)

Table 6: Effect of Cocoa pod husk ash (CPHA) and NPK fertilizer on soil chemical composition at Akure

Treatments	pH	OM (%)	N (%)	P Mg/kg	K Cmol/kg	Mg Cmol/kg	Ca Cmol/kg
0 t ha^{-1} CPHA	7.4^{e}	2.6^{e}	0.06^{e}	7.9^{g}	0.18^{e}	1.0^{f}	1.8^{e}
2 t ha^{-1} CPHA	8.4^{e}	2.8^{d}	0.10^{a}	7.9^{g}	0.38^{b}	1.1^{e}	2.2^{e}
4 t ha^{-1} CPHA	8.6^{b}	2.8^{d}	0.08^{b}	8.0^{g}	0.54^{a}	1.2^{d}	2.0^{d}
6 t ha^{-1} CPHA	8.6^{b}	3.7^{a}	0.11^{a}	9.2^{e}	0.51^{a}	1.4^{e}	2.5^{b}
8 t ha^{-1} CPHA	9.2^{a}	3.3^{b}	0.10^{a}	13.1^{d}	0.57^{a}	1.7^{b}	2.2^{e}
10 t ha^{-1} CPHA	9.6^{d}	3.0^{e}	0.09^{b}	13.6^{e}	0.41^{b}	4.0^{a}	5.7^{a}
NPKF 200 kg ha^{-1}	7.9^{d}	3.3^{b}	0.10^{a}	14.4^{a}	0.35^{b}	1.1^{e}	2.1^{d}

2, 4, 6, 8 and 10 t ha^{-1} also N at Akure compared with application of CPHA, NPKF increased soil N and P but CPHA increased soil K and pH than NPKF. Therefore, CPHA is a more effective source of K than NPKF.

Increases in soil pH and cations adduced to CPHA is consistent with its alkaline nature. A pH ($CaCl_2$) of 8.5 was recorded in the present work for CPHA. Other analysis data for CPHA were 0.59% N, 0.49% P, 11.7% K, 2.7% Ca and 0.67% Mg. Hence, CPHA was able to increase the macronutrient content of soil and nutrients uptake by kola seedlings (Table 7 and 8). The relatively high value of K is consistent with the use of CPHA as K source (Adu-Dapach, 1994). Analysis of CPH by Sobamiwa and Longe (1994). Analysis of CPH by Sobamiwa and Longe (1994) showed that it contained Ca, K, P and Mg and lower amounts of Na, Zn, Fe, Cu and Mn. Shittu(Unpublished) gave values of 5.9% N,, 0.31% P, 5.7% K, 0.56% Ca and 1.00% Mg for rotten cocoa pod husk. Other workers (Obi and Ekperigin, 2001; Van Reuler and Janssen, 1996) found that ash derived from plants had liming effect on soil.

Increases in soil pH due to application of CPHA should have also enhanced microbial activity (Bath and Arnebrant, 1994) thereby enhancing nutrient release from native organic sources and formation of organic matter. Hence increase in soil organic matter was observed with application of CPHA.

The CPHA and NPKF significantly increased root nutrient uptake (Table 7 and 8). Root N, P and K concentrations increased with level of CPHA. At Akure root MG uptake was also increased with level of CPHA. Compared with NPKF, CPHA at 2, 4, 6, 8 and 10 t ha^{-1} gave higher values of root P uptake at both locations, at Root K uptake at Akure. Compared with NPKF, 10 t ha^{-1} CPHA gave higher root P, K and MG uptake at both locations and higher root concentration at Akure. However, NPKF gave higher root N at Ibadan. Compared with NPKF 2, 4, 6, 8 and 10 t ha^{-1} CPHA gave higher values of root Ca uptake determined for Ibadan only. These findings ascertain that CPHA increased availability of N, P, K, Mg and Ca in soil which led to increased uptake of the nutrients by Kola seedlings. The increased uptake of the nutrients led to increased growth of kola seedlings (Table 1-4). These findings are consistent with earlier findings of Owolabi *et al* (2003), Odedina *et al* (2003) Van Reular and Janssen (1996), Nottidge *et al* (2005a, 2005b) and Awodun and Oejniyi (2005) who found that addition of types of ash to soil at 2 to 8 t ha^{-1} increased macronutrients status of soil and uptake of N, P, K, Ca and Mg by rice, tomato, papper, maize, yam, peanut and the yield of the crops.

Table 7: Effect of cocoa pod husk ash (CPHA) and NPK fertilizer (NPKF) on root nutrient status of kola seedlings at Ibadan

Treatments	N%	Pg/plant	Kg/plant	Mg/plant	Cag/plant
0 t ha^{-1} CPHA	1.1^{d}	0.41^{c}	0.08^{d}	0.03^{d}	0.09^{d}
2 t ha^{-1} CPHA	3.4^{b}	1.21^{a}	0.20^{c}	0.07^{b}	0.14^{c}
4 t ha^{-1} CPHA	3.0^{b}	1.05^{b}	0.20^{c}	0.07^{b}	0.24^{b}
6 t ha^{-1} CPHA	2.3^{c}	1.72^{d}	0.20^{c}	0.06^{c}	0.24^{b}
8 t ha^{-1} CPHA	3.0^{b}	1.00^{b}	0.26^{a}	0.06^{c}	0.16^{c}
10 t ha^{-1} CPHA	3.4^{b}	0.85^{c}	0.26^{a}	0.06^{c}	0.13^{c}
NPKF (200 kg ha^{-1})	4.2^{a}	0.79^{d}	0.24^{b}	0.11^{a}	0.09^{d}

Values with different superscripts in a column are significantly different (p>0.05)

Table 8: Effect of cocoa pod husk ash (CPHA) and NPK fertilizer (NPKF) of root nutrient status of kola seedling at Akure

Treatments	N%	Pg/plant	Kg/plant	Mg/plant	Ca/plant
0 t ha^{-1} CPHA	5.1^{c}	1.4^{f}	0.08^{d}	0.22^{d}	0.13^{c}
2 t ha^{-1} CPHA	5.4^{c}	2.1^{e}	0.20^{c}	0.44^{c}	0.19^{b}
4 t ha^{-1} CPHA	7.5^{d}	1.5^{e}	0.20^{c}	0.47^{b}	0.17^{b}
6 t ha^{-1} CPHA	9.4^{b}	2.6^{b}	0.20^{c}	0.55^{b}	0.19^{b}
8 t ha^{-1} CPHA	5.4^{c}	1.8^{d}	0.26^{a}	0.40^{c}	0.19^{b}
10 t ha^{-1} CPHA	12.9^{a}	2.9^{a}	0.26^{a}	0.68^{a}	0.24^{a}
NPKF (200 kg ha^{-1})	9.5^{b}	1.8^{d}	0.24^{b}	0.39^{c}	0.19^{b}

Values with different superscripts in a column are significantly different (p>0.05)

The better growth of kola seedlings given by CPHA applications might be due to longer retention of nutrients against leaching compared with inorganic fertilizer. Aside from this, CPHA also served as a liming materials by increasing availability of cations and hence soil pH (Table 5 and 6) compared with NPKF. The liming effect is expected to be advantageous to kola seedlings in the slightly acidic soils.

The highest values of growth parameters given by CPHA applications might be due to longer retention of nutrients against teaching compared with inorganic fertilizer. Aside from this, CPHA also served as a liming material by increasing availability of cations and hence soil pH (Table 5 and 6) compared with NPKF. The lining effect is expected to be advantageous to kola seedlings in the slightly acidic soils.

The highest values of growth parameters given by 4 or 6 t ha^{-1} CPHA could be due to lower values of root uptake of Ca given by 8 and 10 t ha^{-1} CPHA (Table 7). Deficiency of Ca manifests as failure of terminal buds and apical tips develop (Tisdale and Nelson, 1966). Availability of Ca determines seedling growth. Odedina *et al*. (2003) recommended 6 t ha^{-1} of ash for cultivation of pepper and 2 t ha^{-1} for tomato, Owolabi *et al*. (2003) recommended 2 t ha^{-1} wood ash for maize and yam and the same recommendation was given by Awodun and Ojeniyi (2005) for groundnut.

CONCLUSIONS

Cocoa pod husk ash could be used to improve N, P, K, Ca and Mg supply to kola seedling in lieu of insufficient or lack of supply of NPK fertilizer. It ensures availability of cations and has a lining effect. Its use led to significant growth of kola seedling, It is recommended for use at 4 t ha^{-1}.

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