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Comparative effects of NPK fertilizer, cowpea pod husk and some tree crops wastes on soil, leaf chemical properties and growth performance of cocoa (*Theobroma cacao* L.)

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A nursery experiment was carried out in Akure (rain forest zone), south-western Nigeria to study relative effect(s) of some organic wastes as fertilizers on growth performance, soil and leaf chemical composition of cocoa seedlings (*Theobroma cacao* L.) in the nursery. The experiment comprised of five treatments: Cowpea Pod Husk (CPH) (2.5 t/ha), cocoa pod husk ash (CPHA) (2.5 t/ha), kola pod husk (KPH) (2.5 t/ha), NPK15-15-15 (2.5 t/ha) and control (no fertilizer application). Each treatment was applied to 2.5 kg of soil filled polythene bags containing cocoa seedlings. The experiment was arranged in completely randomized design (CRD) with three replications. The organic wastes increased significantly (P>0.05) the plant height, stem diameter, leaf area, number of leaves, fresh root and shoot weights and dry root and shoot weights of cocoa seedlings. The treatments also increased significantly (P>0.05) soil and leaf N, P, K, Ca, Mg, Na, soil pH and organic matter (OM) content relative to the control. Kola pod husk (KPH) was the most effective in improving cocoa growth, leaf and soil chemical composition.

Key words: Cocoa, growth, organic matter, NPK, cowpea pod husk, cocoa pod husk ash, kola pod husk.

INTRODUCTION

Cocoa is one of the most important tropical crops (FAOSTAT, 2006). West Africa contributes about 70% of the world's cocoa production. The crop significantly contributed to the economies of countries in this sub-region, as well as economics of many other countries in Central America and South East Asia. Nigeria is the fourth largest producer of cocoa in the world with an estimated production of 485,000 metric tons in 2006 (FAOSTAT, 2006). Cocoa is therefore a major commodity crop cultivated in Nigeria and is a major raw material used in the production of cocoa powder (for beverage drink), various chocolate based products, biscuits and confectioneries. Processed cocoa bean is also used to make sweets, sweetening products, cocoa butter (used in making chocolate), perfume, and in pharmaceuticals. Locally, cocoa bean is used in cooking soup that has resemblance of okra and in treating various abdominal problems or ailments (Opeke, 2005). The production of cocoa in Nigeria has witnessed a downward trend since the early 1970s due to numerous factors like ageing trees, ageing farmers, wrong application of recom-mended agronomic techniques by farmers, effects

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of pests and diseases and deficiencies in macro and micro nutrients in the soils (Adejobi et al., 2011a).

Previous studies have attributed this yield decline essentially to soil nutrients imbalance (Ojeniyi et al., 1981). One way of combating this problem is the use of fertilizer. However, African farmers use very little fertilizer (8 kg/ha) compared to their counterparts in other parts of the agrarian world; hence, Africa's soils are increasingly depleted of nutrients (IFDC, 2008/2009). This is particularly true with cocoa farmers in Nigeria.

Ogunlade et al. (2009) reported that more than 85% of cocoa farmers in Nigeria do not use fertilizers on cocoa. Reasons for this low usage of fertilizers vary from lack of farmers' knowledge of the nutrients status of their soils to scarcity and high cost of fertilizers where available. The need to pay attention to soil fertilization is now almost as important as the control of capsids and black-pod disease in cocoa. Ayanlaja (2002), Adejobi et al. (2011a, b, c, d) and Moyin-Jesu (2008) reported the use of organic residues such as animal manures, urban refuse, agro-industrial processing wastes, animal dungs, refuse dump compost, pit latrine compost, foot of the hill compost, mulching, passive refuse dump in home gardens and alley cropping with appropriate nitrogen fixing shrubs, have been found capable of increasing and balancing soil nutrients with consequential increase in yield and crop performance.

The main objective of this study therefore was to examine the influence of different organic wastes on soil, leaf chemical composition and growth performance of cocoa seedlings.

MATERIALS AND METHODS

The experiment was carried out at Federal college of Agriculture, Akure between 2010 and 2011. Akure is located in the sub-humid region with distinct dry and wet seasons. The annual rainfall ranges from 1100 to 1300 mm per annum, temperature ranges between 24 and 30°C and relative humidity is about 85%.

Soil sampling and analysis before planting

Soil samples were randomly collected from 0 to 15 cm depth on the site. The soils were bulked, air dried and made to pass through a 2 mm sieve for chemical analysis. The soil pH (1:1 soil/water) was measured using pH meter. Organic matter was determined by the Murphy blue coloration and determined on a spectronic 20 at 882 um (Murphy and Riley, 1962). Soil potassium (K), calcium (Ca) and Magnesium (Mg) were extracted with lMNH$_4$ OAC, PH$_7$ and were determined with flame photometer; Mg was determined with an atomic absorption spectrophotometer. The total nitrogen (N) was determined by the Microkjedahl method (AOAC, 1990).

Processing of the organic residues used for the experiment

Cocoa pod husk ash (CPHA) and kola pod husk (KPH) were both obtained from cocoa and kola processing departments of Cocoa Research Institute of Nigeria (CRIN), Ibadan. Cowpea pod husk (CPH) was obtained from near-by farm in Ibadan, Oyo State while NPK 15-15-15 fertilizer was obtained from Mikky Farm Limited, Akure, Ondo State. Cocoa pod husk, cowpea pod husk and kola pod husk were sun dried for 32 h. Only cocoa pod husk was bunt to ash and allowed to cool for another 32 h, bagged and kept in a dry place. Kola and cowpea pod husk were ground with heavy mortal, bagged and kept in a dry place.

Chemical analysis of the organic material used

Two (2) grams each of the processed forms of the organic material used were analysed for nutrient composition using the standard procedure as described by Udo and Ogunwale (1986).

Nursery experiment

Mature, disease-free and ripe cocoa pods were harvested from cacao plantation of the Cocoa Research Institute of Nigeria (CRIN). The pods were broken and the beans were hand- scooped for planting. The bulked soil taken from the site (0 to 15 cm depth) of the experiment was sieved to remove stones and plant debris and 2.5 kg of the sieved soil was placed into a polythene bag (25 × 13 cm). There were 5 treatments: 2.5 t/ha cowpea pod husk (CPH), 2.5 t/ha cocoa pod husk ash (CPHA), 2.5 t/ha kola pod husk (KPH), 2.5 t/ha NPK 15-15-15 and the control (no fertilizer application). Two cocoa beans were sown per polythene bag arranged in completely randomized design (CRD) and later thinned to one seedling per polythene bag. The amount of the treatments were applied using spot method a month after sowing, the parameters such as plant height, number of leaves, leaf area, stem girth and number of branches were recorded from 8 to 32 weeks after planting. At 32 weeks after planting in the nursery, the seedlings were carefully removed from the polythene bags for the measurement of shoot and root lengths, fresh shoot and root weights; then oven dried and both dry shoot and root weights were taken before they were finally analysed for N, P, K, Ca and Mg contents.

At the time of taking the shoot weight, soil samples were taken from each of the polythene bag, air dried and sieved for analysis of major elements (soil N, P, K, Ca, Mg, pH and OM) as described earlier.

RESULTS AND DISCUSION

The result of the initial physico-chemical properties of the soil used for the experiment is presented in Table 1. The soil which was classified as an Affisol belonging to Akure series (Soil Survey Staff, 1999) had pH (H_2O) of 5.40, Organic matter (0.52%), total N (0.11%), available P (6.05 mg/kg), exchangeable K, Ca, and Mg being 1.20, 1.42 and 0.95 mole/kg, respectively. The values for organic matter, N, P, and Mg were generally low and fell below the critical level required for optimal performance of most tree crops in Nigeria (Egbe et al., 1989). With low N, P, K, Ca, Mg and organic matter, it is quite obvious that the soil is inherently low in fertility and therefore expected to show positive response to soil amendment. The insufficient levels of the major nutrients in the soil showed that the soil is depleted and would not be able to meet the nutritional needs of the cocoa plants unless external nutrients supply is made for the soil to be able to support optimum growth of cocoa plants. The soil particle size distribution indicated that the overall mean sand, silt

Table 1. Soil physiochemical composition before planting cocoa.

Soil properties	Value
Physical properties	
Sand	76.02%
Silt	16.25%
Clay	7.73%
Textural class	Sandy loam
Chemical properties	
Soil pH (H_2O)	5.40
Organic matter	0.52%
Organic carbon	0.25%
Nitrogen	0.11%
Available P	6.05 mg/kg
Exchangeable bases	
K^+	1.20 cmol/kg
Ca^{2+}	1.42 cmol/kg
Mg^{2+}	0.95 cmol/kg
Mn^{2+}	0.89 cmol/kg
Exchangeable acidity	
Al^{3+}	1.39 cmol/kg
H^+	0.12 cmol/kg
ECEC	6.97

and clay contents of the soil were 76.02, 16.25 and 7.73%, respectively. The clay + silt values were generally below 32% estimated to be adequate for soils considered to be ideal for tree crop production especially cocoa plant (Egbe et al., 1989).

Table 2 presents data on the nutrient composition of the organic materials used for raising the cocoa seedlings; cowpea pod husk (CPH) contained 4.02% OM, 22.93 mg/kg P, 8.25 mg/kg Mg, 4.91 mg/kg Ca and 4.19 mg/kg Na. Kola pod husk (KPH) on the other hand had 2.6% N, 3.21% OM, 6.51 mg/kg P, 1.09 mg/kg Mg, 2.66 mg/kg Ca and 2.61 mg/kg Na. On the contrary, cocoa pod husk ash (CPHA) contained 2.0% OM, 1.02% N, 4.02 mg/kg P, 5.31 mg/kg K, 1.08 mg/kg Mg. 3.60 mg/kg Ca and 3.06 mg/kg Na. Cocoa pod husk ash had high K with low N and P. The low value of N in CPHA might be as a result of volatilization during the burning process since the carbon present in the material has been partially destroyed by burning. This is consistent with the findings of Ajayi et al. (2007) and Odedina et al. (2003) that cocoa pod ash contained N, P, K, Ca and Mg. The high pH of the organic materials especially the CPHA, is an indication that the soil used for the conduct of the experiment which is confirmed to be acidic will benefit positively from their addition, and hence, moderate the acidity of the soil. This finding is in agreement with the earlier results of Ayeni et al. (2008a, b) and Ajayi et al. (2007a, b) that CPHA increased soil pH due to its liming effects on the soil. The growth parameters of cocoa seedlings as influenced by different organic fertilizers application are presented in Table 3.

The organic fertilizer materials positively and significantly affected the growth parameters of cocoa seedlings such as plant height, stem diameter, number of leaves per plant and leaf area relative to control. Kola pod husk produced the highest plant height, number of leaves per plant and leaf area respectively relative to control and other fertilizer materials; this was closely followed in descending order by NPK 15-15-15, cocoa pod husk ash, cowpea pod husk and control (KPH > NPK 15-15-15 > CPHA >CPA> control). Generally, the values of KPH with respect to these parameters were either higher or comparable to the in-organic fertilizer (NPK 15-15-15) and other organic material.

Fresh and dry root weight of cocoa seedlings (Table 4) showed that NPK fertilizer and organic materials of plant origin were comparable in their values. However, values due to organic fertilizers of plant origin were higher compared to that of inorganic origin (NPK 15-15-15 fertilizer). This might be due to presence of other vital nutrient elements presence in the organic fertilizer mate-rials (Ca, Mg, organic carbon and other micronutrients) that are required for good seedling growth which are absent in the NPK 15-15-15 fertilizer. Similar results were obtained for both fresh and dry shoot weight of cocoa seedlings with kola pod husk having the highest shoot weight (13.13 g) relative to control (6.33 g). The mean weight differences recorded for KPH and NPK 15-15-15 were not significantly ($p = 0.05$) different from each other although the highest response was recorded with KPH. CPH and CPHA recorded similar mean values of 10.00 and 9.00 g, respectively for dry shoot weight while KPH was significantly ($p \geq 0.05$) higher relative to other materials and control.

The effects of the treatments on the chemical properties of the soil as presented in Table 5 shows that all the organic materials and most importantly the cocoa pod husk ash increased the soil pH significantly ($p \leq 0.05$) compared to NPK and control, respectively. This findings is in agreement with the result of Nottidge et al. (2007) that affirmed the role of ash as a liming material and effective source of nutrients for crops such as vegetables, maize and cocoa (Odedina et al., 2003; Ayeni et al., 2008).

The soil N contents ranged between 0.11 to 0.99 g/kg soil. NPK 15-15-15 significantly increased soil nitrogen content relative to control. The effect of the treatments on soil N status shows the soil was significantly ($p \leq 0.05$) and positively affected by all the treatments. The effect of kola pod husk on soil N was more pronounced followed by CPHA and CPH, respectively. The difference between NPK 15-15-15 and KPH in respect to soil was not significant (Table 5). The effects of the applied organic

Table 2. Chemical analysis of the organic manures used for the experiment.

Treatment	pH (H_2O)	C/N ratio	OM (%)	N (%)	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	Ca (mg/kg)	Na (mg/kg)
CPH	7.02	6.00	4.02	2.63	22.93	3.89	8.25	4.98	4.19
CPHA	7.20	9.50	2.00	1.02	40.21	5.31	1.08	3.60	3.06
KPH	6.99	5.60	3.21	2.68	6.51	3.29	1.09	2.66	2.61

CPH, Cowpea pod husk; CPHA, cocoa pod husk ash; KPH, kola pod husk.

Table 3. The growth parameters of cocoa seedlings between 4 to 24 weeks after planting under different organic fertilizer application.

Treatment	Plant height (cm)	Number of leaves	Stem girth (cm)	Leaf area (cm^2)
CPH	27.81^b	9.55^b	2.24^a	47.09^b
CPHA	27.82^b	10.46^a	2.19^a	45.91^b
KPH	30.56^a	11.38^a	2.19^a	53.64^a
NPK 15-15-15	27.87^b	11.27^a	2.16^a	52.26^a
Control	19.96^c	6.86^c	1.13^b	28.96^c

CPH, Cowpea pod husk; CPHA, cocoa pod husk ash; KPH, kola pod husk.
Treatment means within each column followed by the same letter are not significantly different from each other using Duncan multiple range test at 5% level.

Table 4. The yield parameters of cocoa seedlings under different organic fertilizer application.

Treatment	Fresh root weight (g)	Dry root weight (g)	Fresh shoot weight (g)	Dry shoot weight (g)
CPH	6.30^a	5.60^a	12.86^c	10.00^b
CPHA	7.30^a	3.80^b	14.3^{ab}	9.00^b
KPH	7.53^a	3.95^b	18.66^a	13.13^a
NPK 15-15-15	6.86^a	2.85^b	15.90^b	12.83^a
Control	3.37^b	2.88^b	10.00^c	6.33^c

CPH, Cowpea pod husk; CPHA, cocoa pod husk ash; KPH, kola pod husk. Treatment means within each column followed by the same letters are not significantly different from each other using Duncan multiple range test at 5% level.

Table 5. Soil chemical analysis after the experiment under different organic fertilizer application.

Treatment	Soil pH (H_2O) 1:1	Organic carbon (g/kg)	Organic matter (%)	N (%)	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	Ca (mg/kg)	Na (mg/kg)
CPH	7.05^a	2.05^a	3.59^a	0.20^b	12.66^c	1.11^a	2.21^a	4.10^a	1.13^c
CPHA	7.38^a	1.53^b	2.15^b	0.27^b	40.00^a	1.88^a	1.98^b	3.19^b	1.09^a
KPH	7.28^a	2.78^a	2.46^b	0.62^a	16.00^c	1.31^a	2.01^a	3.11^a	0.66^b
NPK 15-15-15	5.03^b	1.79^b	0.85^d	0.99^a	20.00^b	1.40^a	1.10^b	2.93^b	0.60^b
Control	5.95^b	1.00^b	0.56^d	0.11^c	12.00^d	1.20^a	0.58^c	1.42^c	0.50^b

CPH, Cowpea pod husk; CPHA, cocoa pod husk ash; KPH, kola pod husk. Treatment means within each column followed by the same letters are not significantly different from each other using Duncan multiple range test at 5% level.

material on soil P revealed that CPHA gave significantly higher mean values relative to control and NPK 15-15-15. This might not be unconnected to the higher P present in the material as revealed by the analysis of the materials (Table 2). Similarly, all the organic materials improved soil K, Mg, Ca, and Na, respectively relative to the control. CPHA recorded the highest value of 1.88 mg/kg K followed by NPK 15-15-15 (1.40 mg/kg). CPH recorded the least soil K value. There is no significant difference among all the treatments applied. The amount of Mg, Ca and Na were also positively influenced with organic fertilizers addition irrespective of sources. This result is

Table 6. The leaf chemical composition under different organic manure application.

Treatment	N (%)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)
CPH	1.98[a]	1.44[a]	5.94[b]	2.08[a]	2.11[a]	2.40[a]
CPHA	1.48[b]	1.24[b]	7.08[a]	1.08[b]	1.91[b]	1.99[b]
KPH	1.49[b]	1.31[b]	6.01[a]	0.73[c]	2.06[a]	1.99[b]
NPK 15-15-15	1.93[a]	1.20[b]	5.48[b]	2.06[a]	1.88[b]	1.08[b]
Control	1.00[c]	0.27[c]	0.81[c]	0.83[c]	0.92[c]	1.00[b]

CPH, Cowpea pod husk; CPHA, cocoa pod husk ash; KPH, kola pod husk. Treatment means within each column followed by the same letter are not significantly different from each other using Duncan multiple range test at 5% level.

consistent with the findings of Odedina et al. (2003) who reported that cocoa pod husk ash significantly increased soil OM, N, P, K, Ca and Mg, respectively. Adejobi et al. (2011a, b), in their work on the effects of organo-mineral fertilizer and cocoa pod husk ash in the soil, leaf chemical composition and growth of coffee concluded that combined application of organo-mineral fertilizer and cocoa pod husk ash increased soil N, P, K, Ca, Mg and pH. The nutrients element composition of the cocoa leaf as affected by different organic manure application is shown in Table 6. The leaf N and P composition of cocoa seedlings was either comparable or higher than the NPK 15-15-15 in leaf nutrient composition. The mean values in the fertilizer treated seedlings were significantly higher compared with that of control. Similar trend as obtained in leaf N and P compositions was recorded with Ca. CPH gave a significantly higher value relative to control.

The difference in values recorded for CPH and NPK 15-15-15 were comparable, though CPH produced a higher value, the difference was not significant. The leaf Mg contents was higher in CPH relative to control and other applied fertilizer material. The low leaf chemical composition value noticeable with the control is a clear indication that the soil is inherently low in soil fertility and basic nutrients for cocoa seedlings. Hence, application of organic fertilizer amendments is quite necessary for enhanced production.

Conclusion

The use of both chemical and organic fertilisers significantly enhanced cocoa growth parameters, fresh and dry matter yield and leaf and soil chemical com-position. However, addition of organic materials such as CPH, CPHA and KPH as nutrient sources produced a promising effects on cocoa seedlings comparable to inorganic fertilizer; hence, they are advised for the purpose of cocoa seedlings establishment.

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