DOI: https://doi.org/10.67042/njss.2011.wibl3a3j

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

EFFECTS OF ORGANO-MINERAL FERTILIZER AND COCOA POD HUSK ASH ON THE SOIL, LEAF CHEMICAL COMPOSITION AND GROWTH OF COFFEE

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ABSTRACT

A nursery experiment was carried out in Ibadan (rain forest zone), Southwest Nigeria to study relative effect(s) of combined use of organo-mineral fertilizer (OMF) and cocoa pod husk ash (CPHA) on soil chemical properties, nutrient status and growth of coffee seedlings (*Coffea arabica* L.). Eight treatments: 5t/ha CPHA, 20 t /ha OMF, 20 t/ha OMF + 5t/ha CPHA, 15 t/ha OMF + 5 t/ha CPHA, 10t /ha OMF + 5 t/ha CPHA, 5 t/ha OMF + 5 t/ha CPHA and 400kg/ha Urea which translate to 6.25g CPHA, 25g OMF, 25g OMF + 6.25g CPHA, 18.75g OMF + 6.25g CPHA, 12.5g OMF + 6.25g CPHA, 6.25g OMF + 6.25g CPHA and 0.6 Urea per 2.5 kg of soil filled poly bag respectively with a control (no fertilizer) were applied to soil containing seedlings. The organic manures increased significantly [$P<0.05$] the plant height, stem diameter, leaf area, number of leaves, root and shoot length, root and shoot weight of coffee seedlings. The treatments also increased significantly [$P<0.05$] soil and leaf N, P, K, Ca, Mg, Na, soil pH and OM content relative to the control. The 15t/ha OMF + 5 t/ha CPHA was most effective in improving Coffee growth, leaf and soil chemical composition. Therefore, it could be recommended for coffee farmers in Southwestern, Nigeria.

INTRODUCTION

Coffee is an important earner of income, contributing in varying degrees to the national income of the producing countries such as Brazil and Kenya. The roasted and ground beans dissolved in boiling water produced a beverage with stimulating and mood – elevating properties which are well commended universally.

Coffee berries contain considerable amount of nitrogen, phosphorous, potash, iron, zinc, manganese and magnesium and lose an output of nutrient from the soil at harvest which had to be replaced by fertilizer application. Coffee benefits from organic manure either in the form of compost, farmyard manure, human urine, human faeces or composted household refuse. Moyin-Jesu (2008), observed deficiency symptom of N, P, K as revealed by yellow colouration, purple without application of fertilizer. Also, Michori (1981), reported that residue mulch materials are valuable source of plant nutrients for coffee plantation in Kenya, East Africa. Obatolu (1995), reported the use of cocoa pod husk as fertilizer for coffee and maize production. Research

information is rare on the use of organo-mineral fertilizers and cocoa pod husk ash on leaf chemical composition and growth of coffee especially in Nigeria.

Due to inadequate availability of organic manures, it is necessary to study effect of integrated application of organic manures which is the usual practice at the farmers' level. The objective of the study is to determine the effect of sole and combined application of organo-mineral fertilizer and cocoa pod husk ash on the growth and nutrient composition of coffee seedlings and soil chemical composition.

MATERIALS AND METHODS

The trial was conducted between September 2009 to February 2010 in Ibadan, in the Rain Forest Zone of South West Nigeria. The site was located at Cocoa Research Institute of Nigeria (CRIN). Ibadan.

Pre-nursery and Nursery Establishment

In January 2009, air-dried beans were sown in boxes [90 x 60 x 30cm] after filling the seed boxes. The bean boxes were thoroughly watered, mulched and kept under shade. Watering continued everyday in the morning and evening for three weeks until the rains became steady. The seeds germinated about 7 weeks after sowing. For nursery establishment, soil was taken from 0 – 15 cm depth, sieved and placed in a poly bag [25cm x 13cm]. The soil weighed 2.5kg.

The germinated coffee seeds were transplanted into the poly bags. Watering was done immediately to prevent transplanted seedlings from wilting and this continued for one week till proper establishment. A shade was provided over the poly bags containing the germinated seeds to prevent scorching by sun. The organic manures were air-dried for three weeks before being applied on surface soil by spot method four weeks after transplanting.

Soil analysis

Surface (0 – 15cm) soil used for the study was analysed after bulking core samples. The bulked sample was taken to the laboratory, air – dried and sieved to pass through a 2mm screen for chemical analysis. Also, analysis of soil collected for treatments at 24 weeks after planting was done.

The soil pH (1:1 soil / water) was read on the pH meter. Organic matter was determined by the wet oxidation method. Soil P was extracted and measured by the Murphy blue coloration and determined on a spectronic 20 at 882um. Exchangeable soil K, Ca and Mg were extracted with 1M NH_4OAc, pH_7, K and Ca were determined with flame photometer; while Mg was determined with an atomic absorption spectrophotometer. The total N was determined by the Microkjedahl method (AOAC, 1990). Mechanical analysis of the test soil was done using hydrometer method.

Processing of the organic residues used for the experiment

The organo-mineral fertilizer was purchased from Pacesetter Fertilizer Company (PFC) in Ibadan, Oyo State. While cocoa pod husk was obtained from cocoa processing Department of the Institute. It was sun dried for 32 hours then burnt to ash and allowed to cool for another 32 hours, bagged and kept in dry place.

Growth determinations

The growth parameters such as plant height, leaf area, number of leaves, stem diameter and number of branches were recorded from 4 weeks after transplanting [WAT]. Hand weeding was done 4, 8, 12, 16, and 20 weeks after planting (WAP). At 24 WAP in the nursery, the seedlings were carefully removed from the poly bags for the measurement of fresh root and shoot weights. Then, they were dried for determination of dried and shoot weights were. The tissues were analyzed for N, P, K, Ca, Na and Mg contents after wet digestion by acid mixture (AOAC, 1990). The organic fertilizer materials were also analyzed for macro and micro nutrients as carried out in the soil.

Statistical Analysis

The growth and yield data collected in 2009 were analyzed using ANOVA. The treatments were compared using Duncan's Multiple Range Test [P=0.05].

RESULTS AND DISCUSSION

The physical and chemical properties of the soils are presented in Table 1. Based on the established critical levels for the soils in Southwestern Nigeria, the soil was acidic and low in organic matter, [Agboola and Corey, 1973]. The soil nitrogen was more than 0.15% which is considered optimal for most crops [Sobulo and Osiname, 1981]. While the available P is less than 10 mg/kg which is considered as adequate for crop production [Agboola, 1982]. The exchangeable K value was very low and crop grown on this soil is expected to respond to K application using 0.2cmol/kg soil as the critical level. Also, the levels of Ca and Mg were very low indicating poor soil fertility. The soil is texturally sand loam, belonging to Onigambari series, an Alfisol.

CPHA had higher concentration of P, K, Na, and Ca. whereas OMF had higher N. CPHA also had higher C:N and pH (Table 2). The lower N and higher C:N for CPHA is attributable to the volatilization of N during burning of CPH (Ajayi *et al*., 2007a, 2007b), other workers had found that CPHA was effective source of P and base elements.

Relative to control, urea, CPHA, OMF, and combinations of OMF + CPHA increased growth parameters of coffee seedlings especially the combination of 20 t ha^{-1} OMF + 5 t ha^{-1} CPHA, 15 t ha^{-1} OMF + 5 t ha^{-1} CPHA and 10 t ha^{-1} OMF + 5 t ha^{-1} CPHA. Urea also increased plant height, leaf area, number of leaves; branches root and shoot lengths relative to control (Table 3). The OMF and its combination with CPHA increased fresh root weight and fresh shoot and dry yield significantly. The CPHA only increased fresh and dry shoot yield; the increase in the former being significant ($P<0.05$). The combination of 15t/ha OMF + 5t/ha CPHA gave highest values of growth and yield parameters (Table 3 & 4). Hence, the need for OMF can be reduced by adding CPHA. Generally, urea alone did not increase yield parameters (Table 4) relative to control and it did not increase growth parameters such as plant height, stem diameter, number of leaves and branches relative to control, CPHA, OMF, and their combinations increased soil pH, OM, P, K, Na, Mg and Ca. Only 15t/ha OMF + 5t/ha CPHA increased soil N. The treatment also gave highest soil OM, and N, urea increased soil OM (Table 5).

Table 6 showed that application of urea, CPHA, OMF and combination of OMF + CPHA increased significantly nutrient composition of coffee seedlings in case of N, P, K, Mg, Ca and Na. As expected, urea gave higher value of leaf N, whereas 15 t ha^{-1} OMF + 5 t ha^{-1} CPHA gave highest leaf K, Mg and Ca. Therefore, CPHA, OMF, their combinations and urea increased uptake of nutrient by coffee seedlings. Combination 15 t ha^{-1} + 5 t ha^{-1} CPHA which gave highest soil OM, N, leaf K, Mg and K gave highest value for most growth and yield parameters indicating that availability of OM and N, K and Mg dictate strongly the performance of coffee. Ojeniyi (1987), had found that for *Coffea canephora*, root yield was positively correlated with applied N, P in South western, Nigeria and soil organic matter was also correlated with root mass. Aside from organic material (CPHA, OMF) urea alone increased P, K, Mg, Ca and Na concentration. Availability of N which increased growth of seedlings should have led to uptake of nutrients not applied to soil which are naturally present in soil especially in OM. Ojeniyi (1980), recorded that long term NPK application significantly influenced nutrient content of coffee plots in Southwestern, Nigeria. Ojeniyi (1981), reported that acidic fertilizers are known to increase uptake of Mn by *Coffea arabica*. Also, NPK application was reported to increase Cu content in coffee. It was found that combination of 15 t ha^{-1} OMF + 5 t ha^{-1} CPHA mostly improved growth and nutrient status of coffee seedlings. Also, the OMF gave highest value of leaf P and relatively high value of leaf N, this is

consistent with the fact that organic materials are a natural source of major and micro nutrients. The above findings corroborated the need for application of natural source of nutrient in coffee production to ensure balanced nutrition. Ojeniyi (1980; 1981), had observed that application of NPK fertilizer caused deficiency of Ca and Mg in leaves of *Coffea* r*obusta*; although NPK at suitable combination increased coffee yield significantly. Even in unfertilized plantation, deficiency symptoms of N, P, K, and Mg were recorded (Omotosho and Olojola, 1972; Ojeniyi, 1980). Therefore, organic fertilizers such as CPHA and OMF would be effective in increasing coffee seedling performance and nutrient uptake. Odedina *et al*. (2003), found that CPHA significantly increased N, P, K and Ca content of tomato leaf, number and weight of fruit and soil OM, N, P, K, Ca and Mg and pH at Ondo, Southwest Nigeria. The CPHA contained 2.63% N, 0.12% P, 3.9% K and 1.97% Ca. The incubation study by Ayeni *et al*. (2008), showed that CPHA had liming effect on soil by supplying base elements thereby increasing soil pH. The CPHA was found to increase soil OC, N, NH_4 – N, NO_3 – N, available P and exchangeable K, Ca and Mg. The chemical composition of CPHA was given as 8.4% OC, 0.68% N, 0.5% P, 11.9% K, 2.9% Ca and 0.40% Mg, with C:N ratio of 12.3. Data presented by Ojeniyi (2010), showed that C:N for OMF, Pacesetter and Sunshine types, were 3.4 and 11.9 respectively. The lower C:N for OMF compared to CPHA should have aided nutrient release from OMF and enhanced release of nutrients such as N and P which are essential for coffee performance. The synergistic relationship between CPHA and OMF is also attributable to quicker dissolution of base and micro nutrients in CPHA compared with OMF which has to be decomposed and the organic nutrients mineralized. Ayeni *et al*. (2009) found that CPHA and poultry manure added N, P, K, Mg, Zn, Cu and Fe when combined with NPK fertilizer. Also, the OMF is expected to have more residual effect on soil nutrient content and crop yield compared with CPHA and had that advantage when used with CPHA (Makinde *et al*., 2010). The later would have benefited coffee seedling which is not an annual crop. A number of studies have observed that types of OMF increased yield and extended productivity in crops (Makinde *et al*., 2010, Ojeniyi *et al*., 2009, Ojeniyi and Adejobi, 2002).

Table 1

Soil Properties	**Value**
Physical Properties	
Sand	642.02 g kg^{-1}
Silt	136.56 g kg^{-1}
Clay	139.55 g kg^{-1}
Textual Class	Sand Loam
Chemical Properties	
PH (H_2O) 1:1	5.26
Organic Carbon	2.73 g/kg
Organic Matter	0.55%
Total Nitrogen	0.04g/100g
Available Phosphorus	2.00 mg/kg
Exchangeable bases	
K+	0.12 cmol kg^{-1}
Ca++	0.50 cmol kg^{-1}
Na+	0.93 cmol kg^{-1}
Mg++	2.80 cmol kg^{-1}
Mn++	0.03 cmol kg^{-1}
Exchangeable acidity	
Al+++	0.23 cmol kg^{-1}
H+	0.12 cmol kg^{-1}
ECEC	5.14 cmol kg^{-1}
Base Saturation	82%

Table 2: Chemical Analysis of the Organic Fertilizer use for the experiment

Treatment	pH H_{2O}	C/N Ratio	OM %	N %	P mg kg^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	Ca mg kg^{-1}
OMF	3.90	6.2	6.3	6.36	16.36	2.29	1.67	1.9	3.4
CPHA	7.21	9.5	2.0	1.02	40.26	5.01	3.06	1.8	3.6

Table 3: The Growth parameters of Coffee seedlings between 4 – 24 weeks after transplanting from pre-nursery under OMF and CPHA fertilizer applications

Treatments	Plant Height (cm)	Stem diameter (cm)	Leaf Area (cm^2)	Number of leaf	Number of branch	Root length (cm)	Shoot length
5 t/ha CPHA	21.80ab	0.37a	39.47a	13.46a	0.60a	13.43b	15.46b
20 t/ha OMF	20.94ab	0.33a	36.81a	12.40a	0.13b	12.83b	14.32bc
20 t/ha OMF+ 5 t/ha CPHA	18.18b	0.34a	25.17b	14.13a	0.40a	10.13c	13.17c
15 t/ha OMF+ 5 t/ha CPHA	22.57a	0.39a	40.83a	14.33a	0.46a	16.96a	19.65a
10 t/ha OMF+ 5 t/ha CPHA	21.95b	0.47a	26.55b	12.60a	0.26b	12.13b	15.22b
5 t/ha OMF+ 5 t/ha CPHA	17.36b	0.26a	20.40c	8.73b	0.01c	8.8d	11.09d
400kg/ha Urea	15.24b	0.25a	20.14c	8.00b	0.33b	10.6c0	14.36c
Control	12.24c	0.22a	15.60d	6.00b	0.01c	7.00d	10.23d

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 4: The yield parameters of Coffee Seedlings 24 weeks after transplanting under different levels of OMF + CPHA fertilizer application.

Treatment	Fresh Root Weight (g)	Dry Root Weight (g)	Fresh Shoot Weight (g)	Dry Shoot Weight (g)
5 t/ha CPHA	1.66c	1.33a	22.00a	4.66b
20 t/ha OMF	5.33a	2.00a	22.00a	4.66b
20 t/ha OMF+ 5 t/ha CPHA	5.33a	2.00a	16.66b	6.33a
15 t/ha OMF+ 5 t/ha CPHA	6.33a	2.66a	23.66a	8.00a
10 t/ha OMF+ 5 t/ha CPHA	3.33b	1.66a	17.00b	8.00a
5 t/ha OMF+ 5 t/ha CPHA	3.00b	2.00a	11.00bc	3.77b
400kg/ha Urea	1.66c	1.00a	4.00c	2.22b
Control	1.66c	1.00a	4.33c	3.36b

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 levels of OMF + CPHA

Treatments	Soil PH (H_2O) 1:1	Organic Carbon (OC) g/kg	Organic Matters (OM) %	N %	P mg/kg	K mg/kg	Na mg/kg	Mg mg/kg	Ca mg/kg
5 t/ha CPHA	5.57ab	2.26bc	3.90	0.36ab	5.99d	0.77b	0.72b	2.00b	4.50b
20 t/ha OMF	6.44a	2.30bc	3.96c	0.33b	11.62c	0.33b	0.78b	1.90b	4.10e
20 t/ha OMF+ 5 t/ha CPHA	6.28a	2.40b	4.16b	0.43ab	31.64a	1.36a	1.72a	2.00b	3.60bc
15 t/ha OMF+ 5 t/ha CPHA	6.02a	2.53b	4.36a	0.52a	19.99b	0.50c	0.76c	1.20c	4.00c
10 t/ha OMF+ 5 t/ha CPHA	5.67aa	1.05d	1.82e	0.16c	2.91e	0.76b	0.79c	1.90b	4.20c
5 t/ha OMF+ 5 t/ha CPHA	6.21a	2.26bc	3.90c	0.34b	19.7ab	1.21a	0.63c	2.60a	6.20a
400kg/ha Urea	5.21ab	2.05d	3.53d	0.32b	5.92d	0.46c	0.57c	1.30c	3.00c
Control	4.61b	2.83a	0.46f	0.42ab	3.56e	0.54c	0.57c	0.20d	3.90c

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 6: The leaf chemical composition under different levels of OMF + CPHA.

Treatment	N %	P Mg/kg	K Mg/100g	Mg Mg/100g	Ca Mg/100g	Na Mg/100
5 t/ha CPHA	3.1c	8.8h	13.4b	2.9ef	11.2g	5.2bc
20 t/ha OMF	4.2b	23.3a	10.0d	3.8d	19.2b	4.1d
20 t/ha OMF+ 5 t/ha CPHA	2.2d	10.8f	6.6e	2.7f	10.5h	3.6e
15 t/ha OMF+ 5 t/ha CPHA	3.0c	12.6d	15.6a	4.8b	22.4a	5.5b
10 t/ha OMF+ 5 t/ha CPHA	3.1c	13.6c	13.7b	2.5f	12.8f	5.5b
5 t/ha OMF+ 5 t/ha CPHA	4.0b	11.7e	14.9a	3.4de	12.9f	6.2a
400kg/ha Urea	5.3a	16.7b	11.4c	4.3c	16.0c	3.8de
Control	1.0c	6.4g	8.4c	2.5a	8.5d	2.9c

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Text at 5% level

CONCLUSION

It was observed from the results that the combined application of organo-mineral fertilizer [OMF] and cocoa pod husk ash [CPHA] manures applied at 15 t/ha OMF + 5 t/ha CPHA (18.75g OMF + 6.25g CPHA /2.5kg poly-bag) increased the soil, leaf N, P, K, Ca, Mg, soil pH, OC, OM, and plant height, stem girth, number of leafies, leaf area, root and shoot length, fresh root and shoot weight, and dry root and shoot weight of coffee seedlings compared with other combinations, CPHA or urea alone. The combination is recommended for optimum growth of coffee seedlings. This recommendation was based on the fact that both OMF and CPHA were effective sources of macro nutrients.

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