Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.27, 2014

Effects of Organic Amendments on Cocoa Soil and Leaf Nutrient Contents

Akanbi, O. S. O[1*] Famaye, A. O[2] Ibiremo, O. S[1] Ipinmoroti, R. R[1] Ogunlade, M.O[1]
Oloyede, A. A[2] Ayegbonyin, K[2] Ojeniyi, S.O[3]
1.Soils and Plant Nutrition Section, Cocoa Research Institute of Nigeria, P.M.B.5244, Ibadan, Nigeria
2.Agronomy and Soils Division, Cocoa Research Institute of Nigeria, P.M.B.5244, Ibadan
3.Federal University of Technology, P.M.B 704, Akure
Correspondence authors' address: akanbioso2008@yahoo.com

ABSTRACT
Comparative effects of two organic soil amendments on soil and leaf nutrients composition were evaluated on cocoa seedlings planted in 10kg soils in plastic pots at Cocoa Research Institute of Nigeria Headquarters, Ibadan, South-west zone of Nigeria. The treatments consisted of Cocoa pod husk ash (CPHA) and oil palm bunch ash (OPBA) applied at 0, 0.005, 0.010, 0.015, 0.020 and 0.030gmN/ pot which were equivalent to 0, 1, 2, 3, 4 and 5kgNha^{-1} and laid out in a completely randomized design (CRD) in three replicates. Prior to commencement of the study, a composite soil samples were collected, air dried, sieved to pass through a 2mm sieve and was analyzed for its chemical and physical properties. Two cocoa beans were sown per pot and later thinned to one per pot three weeks after emergence. Treatments were imposed on each of the pots one month after emergence. Watering was done twice throughout the period of the experiment. At harvest, soil and leaf samples were collected per treatment, processed and analyzed for leaf and soil nutrients contents. Results show that ash from CPHA and OPBA had a significant ($p< 0.05$) impact on soil N, P, K, Ca, Mg, organic matter and pH at 5kgNha^{-1} . Results also reveal that CPHA and OPBA significantly improved leaf nutrients uptake relative to control treatments.
Keywords: cocoa pod husk ash, oil palm bunch ash, nutrient uptake, organic matter, ash

INTRODUCTION

Most Agricultural lands in Nigeria especially those found in the Southwestern zones of the country are characterized by low fertility status due largely to low level of activity clay, organic matter content, soil N, P, K, Ca and Mg (Awodun and Olafusi, 2007; Ojeniyi and Ighomore, 2004 and Adenle, 2010). In view of this, research scientists have advocated the use of sole or combined organic amendments of both plant and animal origin which are found to be cheap, readily available and environmentally friendly for improving the existing acidic and highly depleted soil of the zones for sustainable crop production. Scarcity and high cost of mineral fertilizers in the market coupled with unfavorable government policies have also contributed to intensification of research into low cost and locally sourced organic materials that could complements the inorganic soil amendments which are rarely available where and when needed. The aim of this study therefore, was to evaluate the effects of organic amendments on the soil and leaf nutrients composition. **MATERIALS AND METHODS**

A greenhouse experiment was conducted at the Cocoa Research Institute of Nigeria, Ibadan, in the rain forest zone of southwestern Nigeria to evaluate the effect of CPHA and OPBA on acidic soil and its influence on the fertility status of the soil during the cropping season of 2010. The experiment was laid out in completely randomized design (CRD) replicated three times. There were eleven (11) manorial treatments involving a control (no treatment); CPHA and OPBA at 1, 2, and 3, 4 and 5kgNha$^{-1.}$ The materials were applied in ring form and covered with soil four weeks after emergence of Cocoa seedlings. Soil samples were collected before and at harvest six months after treatment application. The initial soil samples were taken at 0 – 15cm depth from one of the old cocoa plantation of Cocoa Research Institute of Nigeria, bulked and prepared for analysis and the rest for greenhouse experiment. Samples were also dried and pass through 2mm sieve. Total soil N was determined by micro kjeldahl method and organic matter by Walkley Black oxidation method. Exchangeable K, Ca, Mg were extracted with neutral 1M ammonium acetate and K was determined with a flame photometer. Ca and Mg were determined by versenate (EDTA) titration method. Available P was determined by colorimetry after Bray- 1 extraction. The soil pH was measured by a glass electrode in 1:1 soil /water suspension. Data were subjected analysis of variance and significant means separated by Duncan's Multiple Range Test (DMRT) at 5% level of significant.

RESULTS AND DISCUSSION

Table1: Initial soil analysis result

Soil properties	Symbols	Units	Values
Nitrogen	N	gkgNha^{-1}	0.75
Phosphorus	P	gkgNha^{-1}	5.74
Calcium	Ca	cmolkg^{-1}	2.31
Magnesium	Mg	cmolkg^{-1}	0.58
Potassium	K	cmolkg^{-1}	0.61
Organic carbon	OC	cmolkg^{-1}	19.2
pH (1:1 Soil/water)	-		6.40
Sand	-	g/kg	682
Silt	-	g/kg	140
Clay	-	g/kg	178
Textural class		Sandy clay loam	

The sand, silt and clay content of the soil as shown in Table 1 were 682, 140 and 178gkg^{-1} soil and found to be adequate to hold enough soil moisture during the short dry spell of the year. This is in agreement with the results obtained by Egbe *et al*., (1989). The soil was slightly acidic with pH of 6.40. Soil organic carbon of 19.20gkg^{-1} soil was also low and below the critical value of 30gkg^{-1} soil recommended for tree crop production in Nigeria (Egbe *et al*., 1989). The low soil pH and organic carbon of the soil is an indication that the soil is low in soil nutrients hence, the need embark on soil management practices that will increase the soil organic matter contents (Ogunwale, 2002) for sustainable and optimal cocoa production on the soil. Similarly, the soil Ca, K, Mg, N and P were also found to be inadequate and below the critical values considered for Cocoa, Coffee, Cashew and Kola production. The low N contents of the ash materials could be linked to volatilization of N during the burning process of the materials (Ajayi, *et al*., 2007a).

Table 2: Chemical composition of the organic materials

Nutrient element composition	Units	CPHA	OPBA
Organic carbon (OC)	gkg^{-1}	1.00	1.70
Nitrogen	gkg^{-1}	0.90	0.25
Phosphorus	gkg^{-1}	0.50	0.20
Potassium	gkg^{-1}	4.30	26.50
Magnesium		0.80	6.90
Calcium		0.30	3.10
pH (1:1 Soil/ water)	-	7.50	8.30

CPHA = cocoa pod husk ash; OPBA = Oil- palm bunch ash

The nutrient compositions of the organic materials used for the study are shown in Table 2. The Nitrogen contents of CPHA and OPBA are 0.90 and 0.25gkgNha^{-1} soil respectively. CPHA is higher in N and P than OPBA while on the other hand, OPBA is higher in K, Ca, Mg, and pH values (Table2). Cocoa pod husk ash composition obtained in this experiment is in line with the work of Ayeni, *et al*.,(2008a, 2008b); Adejobi, *et al*.,(2011) and Akanbi, *et al*.,(2012) that cocoa pod husk ash is richer in K, Ca and Mg. The pH values of both materials ranged between 7.50 for CPHA and 8.30 for OPBA. This is an indication that CPHA and OPBA are suitable liming materials due to the supply of base elements (Odedina *et al*., 2003).

Table 3: Soil chemical properties as influenced by Oil- palm bunch ash addition

Fertilizer rates	**pH (1:1 Soil/H_2O)**	**N**	**P**	**K**	**OC**	**Mg**	**Ca**
		gkg^{-1}		**cmolk^{g-1}**	**gkg^{-1}**	**cmolkg^{-1}**	
Control	6.40^{d}	0.75^{f}	5.71^{e}	0.61^{d}	19.00^{e}	0.58^{e}	2.31^{f}
OPBA @1kgNha^{-1}	6.60^{c}	0.90^{e}	5.96^{d}	0.95^{c}	19.81^{d}	1.92^{d}	3.11^{e}
OPBA @2kgNha^{-1}	6.68^{b}	1.09^{d}	6.07^{d}	0.99^{c}	21.01^{d}	1.96^{d}	3.73^{d}
OPBA @3kgNha^{-1}	6.71^{b}	1.39^{c}	6.83^{c}	1.04^{c}	22.76^{c}	2.01^{c}	4.48^{c}
OPBA @4kgNha^{-1}	6.74^{b}	1.61^{b}	7.25^{b}	1.34^{b}	24.81^{b}	2.20^{b}	4.89^{b}
OPBA @5kgNha^{-1}	6.92^{a}	2.26^{a}	7.83^{a}	1.94^{a}	26.90^{a}	2.60^{a}	5.59^{a}

Means with the same letters along the same column are not significantly different (p< 0.05) from each other. OPBA= Oil- palm bunch ash

Oil palm bunch ash improved the chemical properties of the soil (Table 3). Addition of OPBA to soil significantly ($p<0.05$) enhanced pH values across different rates of application with OPBA at 5kgNha^{-1} recording the highest pH values. This was closely followed by OPBA applied at 4kgNha^{-1}. Control treatment recorded the

least pH values. The increase in soil pH at the end of the trial was probably due to the supply of basic cations into the soil system by the mineralization of the organic materials. Akanbi *et al*., (2012) reported similar trend. The soil total N values at the end of the study due to OPBA addition was higher than the value recorded for the control treatment. OPBA at 5kgNha^{-1} recorded the highest value of N (2.26gkg^{-1}) supply to the soil, the least value was found with control treatment. The differences between 1 and 2kgNha^{-1} OPBA were not significant. The organic material (OPBA) addition significantly ($p<0.05$) increased the soil N, P, K, Ca, Mg and pH respectively relative to control. Of all the rates, 5kgNha^{-1} had the greatest impact on organic matter build up, it accounted for over 25% increase in soil organic carbon build up. The value however decreased as the rates of application reduced. Percentage increase in soil organic carbon ranged between 3.7 to 26.3% respectively. The result of the application of OPBA on soil P and K revealed increase in values of P and K contents by 27.1 and 68.6% respectively. The highest soil available P and K were recorded at 5kgNha^{-1}. Similar trend was recorded for Mg and Ca.

Table 4: Soil chemical properties as influenced by CPHA at 6 months after application

Fertilizer rates	pH(1:1 Soil/H_2O)	N	P	K	OC	Mg	Ca
		gkg^{-1}		cmolkg^{-1}		cmolkg^{-1}	
Control	6.42^{f}	0.72^{e}	5.70^{e}	0.60^{c}	19.10^{f}	0.58^{e}	2.31^{f}
CPHA @1kgNha^{-1}	6.48^{e}	0.95^{d}	6.80^{d}	0.62^{d}	19.82^{e}	1.82^{d}	4.03^{e}
CPHA @2kgNha^{-1}	6.51^{d}	1.13^{d}	6.95^{d}	0.65^{c}	20.91^{d}	1.87^{c}	5.01^{d}
CPHA @3kgNha^{-1}	6.58^{c}	1.35^{c}	7.45^{c}	0.66^{c}	22.81^{c}	1.90^{c}	5.33^{c}
CPHA @4kgNha^{-1}	6.61^{b}	1.84^{b}	7.92^{b}	0.70^{b}	23.90^{b}	1.95^{b}	5.53^{b}
CPHA @5kgNha^{-1}	6.69^{a}	2.32^{a}	8.84^{a}	0.87^{a}	25.93^{a}	2.67^{a}	5.97^{a}

Means with the same letters are not significantly different (p< 0.05) from each other. CPHA=Cocoa pod husk ash.

The CPHA applied irrespective of rates significantly increased the soil pH levels at the end of the experiment. CPHA applied at a rate of 5kgNha^{-1} significantly ($p< 0.05$) enhanced pH by 40% higher than control as shown in Table 4. The amount of soil N increased significantly compared with control. The least soil N value was observed with the control while CPHA applied at a rate of 5kgNha^{-1} recorded highest amount of N into the soil, this was distantly followed by CPHA at 4kgN/ha. Compared with control, CPHA and OPBA at all levels of application significantly ($p<0.05$) increased the values of soil P, K, Ca, Mg and OC. 5kgNha^{-1} of CPHA produced the highest values of these nutrient elements. These improved soil nutrient contents as a result of cocoa pod ash addition agreed with the findings of Ayeni *et al.* (2008b) that application of wood ash increased soil OM, N, P, Ca as well as leaf N and P in their experiment conducted to show the effect of wood ash on raising cocoa seedlings in the nursery. Similarly, Ajayi *et al*.,(2007a) also reported increased soil nutrients due to application of CPHA on Kola seedlings.

Table 5: Leaf nutrient uptake (mg/plant) of cocoa seedlings as influenced by sole CPHA addition six months after application

Fertilizer rates	N	P	K	Ca	Mg
Control	131.5^{e}	28.9^{e}	198.9^{e}	128.5^{e}	19.5^{d}
CPHA @1kgNha^{-1}	205.6^{d}	50.7^{d}	372.1^{d}	268.8^{d}	26.3^{c}
CPHA @2kgNha^{-1}	218^{d}	53.3^{d}	399.0^{c}	317.2^{c}	30.9^{bc}
CPHA @3kgNha^{-1}	252.6^{c}	54.4^{c}	439.0^{b}	349.7^{b}	32.7^{ab}
CPHA @4kgNha^{-1}	301.9^{b}	63.3^{b}	456.1^{b}	353.2^{b}	34.4^{ab}
CPHA @5kgNha^{-1}	438.7^{a}	73.1^{a}	551.8^{a}	417.0^{a}	34.4^{a}

CPHA= Cocoa pod husk ash.

The CPHA positively enhanced leaf tissue contents (Table 5). The leaf N uptake was significantly enhanced by CPHA applied at all levels of application compared with the control at six months after application. Application rate of 5kgNha^{-1} recorded the highest leaf N while the least value was found with the control and 1kgNha^{-1} respectively. The percentage increase in leaf N by CPHA ranged between 36.00 – 70.02%. The leaf P contents increased with increased rates of application. The percentage increases ranged between 42.99 – 60.47%. CPHA applied at 5kgNha^{-1} gave the highest (73.1mg/plant) amount of P in cocoa leaves while control recorded the least values. Similar trend were recorded with amount of K, Ca and Mg uptake respectively. The percentage increase of each of the element by CPHA ranged between 46.55 – 63.95% for K, 52.05 – 69.92% for Ca and 25.44 – 42.99% for Mg respectively. Generally, the differences among the treatments were significant ($p< 0.05$). This observation is consistent with the findings of Ajayi *et al* (2007a, 2007b) who noted a significant increase in root and stem nutrient element of Kola due to CPHA addition.

The improved leaf nutrient uptakes due to application of ash is consistent with the findings of Ayeni, *et al*.,(2008b) that application of wood ash increased leaf N and P as well as soil OM, N, P, K and Ca in the experiment conducted to show the effect of wood ash and sawdust ash on raising cocoa seedlings in the nursery. Ayeni, *et al*., (2010) also found that application of cocoa pod husk ash, NPK 20:10: 10 fertilizer and their combinations increased soil organic matter and major nutrients, tissue N, P and K status as well as agronomic parameters of maize.

Table 6: Leaf nutrient uptake (mg/plant) of cocoa seedlings as influenced by OPBA addition six months after application.

Fertilizers rates	**N**	**P**	**K**	**Ca**	**Mg**
Control	145.5^{e}	35.9^{e}	201.8^{f}	140.5^{f}	25.6^{f}
OPBA @1kgNha^{-1}	219.6^{d}	57.8^{d}	283.2^{e}	280.8^{e}	33.4^{d}
OPBA @2kgNha^{-1}	232.3^{d}	60.5^{d}	411.1^{d}	329.1^{d}	39.6^{c}
OPBA @3kgNha^{-1}	266.4^{c}	66.5c	451.2^{c}	451.6^{c}	43.7^{b}
OPBA @4kgNha^{-1}	315.7^{b}	70.4^{b}	468.3^{b}	365.0^{b}	45.6^{b}
OPBA @5kgNha^{-1}	452.6^{a}	80.2^{a}	560.9^{a}	429.3^{a}	49.8^{a}

OPBA =Oil palm bunch ash

Relative to control, OPBA at all levels of application significantly ($p< 0.05$) improved leaf N, P, K, Ca and Mg respectively (Table 6). The 5kgNha^{-1} OPBA gave the highest leaf contents of each of the nutrient elements. The percentage leaf N increase ranged between 3.37 – 68.2%.This observations is consistent with the results of Ezekiel, *et al*., (2009a, 2009b) who noted that sole and amended form of OPBA had beneficial effects on soil chemical properties. Ojeniyi *et al* (2006) and Ezekiel *et al* (2009a , 2009b) also found that OPBA used alone increased nutrient availability, controlled soil acidity, increased yield of maize and cassava.

Conclusion

The results of this study show that cocoa pod husk ash (CPHA) and Oil palm bunch ash (OPBA) enhanced growth performance of cocoa seedlings, improves both macro and micro nutrients element of the soil and increased the leaf N, P, K, Ca and Mg respectively.

Acknowledgement

The authors wish to appreciate the Executive Director of cocoa Research Institute of Nigeria, Ibadan for the permission given to publish this work and all the Technical staff of Soils and Plant Nutrition Section for their support during the course of this study.

REFERENCES

Adejobi, K. B; Famaye, A. O; Adeniyi, D.O; Akanbi, O. S. O. and Orisajo, S.B.(2011). Comparative effect of organo mineral fertilizer and cocoa pod husk ash on the soil, leaf and chemical composition and growth performance of cocoa (*Theobroma cacao*) in south western Nigeria. Obeche Journal 29 (1): 212 – 217, 2011; ISSN 0078 - 2912

Adenle, (2010): The role of organic matter in sustainable arable farming system in the Tropics. Soil fertility and land Development, 21: 82 – 87.

Ajayi, C. A; M. A; Awodun and S.O; Ojeniyi, (2007a): Comparative effect of Cocoa Husk ash and NPK fertilizer on Soil and Root nutrients content and growth of Kola Seedlings. International Journal of Soil Science (2) 2, 148 – 153.

Ajayi, C. A; M. A; Awodun and S.O; Ojeniyi, (2007b): Effects of cocoa pod husk on growth and stem nutrient uptake of Kola seedlings. Asian Journal of Agricultural Research, 1: 31 – 34.

Akanbi, O.S.O.; Ojeniyi, S.O.; Ipinmoroti, R.R.; Ibiremo, S.O.;Aderolu, I.A.; Famaye, A.A.; Oloyede, A.A. and Orisasona, T.M. (2012): Utilization of ashed Cocoa pod husk and urea fertilizer on growth and dry matter yield of coffee in Ibadan. Alfisol Conference paper presented at 36th Annual Conference of Soil Science Society of Nigeria held at Nsukka, March 12 - 16, 2012.

Awodun, M. A and Olafusi, R. A (2007): Effect of Integrated application of goat manure and urea on soil nutrient content and yield of Okra. Nigerian Journal of Soil Science, 17: 126 – 129.

Ayeni L.S., Adetunji M .T., Ojeniyi S. O., Ewulo B. S. and Adeyemo A. J. 2008a. Comparative and cumulative effect of Cocoa pod Husk ash and poultry soil and maize nutrient content and yield. American-Euroasian Journal of sustainable agriculture, 2(1) 92-97

Ayeni, L. S. (2010): Effect of combined cocoa pod husk ash and NPK fertilizer, on soil properties, Nutrient uptake and yield of Maize (Zea mays).Journal of American science; 2010; 6(3). Pp 79 – 84.

Ayeni, L. S.; Adetunji, M.T. and Ojeniyi, S. O.(2008b) .Comparative nutrient release from cocoa pod ash, poultry manure and NPK 20: 10 :10 and their combinations – Incubation Study, Nigerian Journal of Soil Science, : 18: 114 - 123.

Egbe, N. E; E.A. Ayodele and C. R. Obatolu (1989): Fertilizer use on production of Cocoa, Kola, Coffee, Cashew and Tea in Nigeria. In progress in Tree Crop Research (2nd ed.). Cocoa Research Institute of Nigeria, Ibadan. pp. 28 – 38.

Ezekiel, P. O.; Ojeniyi, S. O.; Asawalam, D. O. and Awo, A.O. Effects of Oil palm bunch ash on growth and root yield of sweet and bitter cassava. Nigerian Journal of Soil science, 2009a: 19, 6 - 10

Ezekiel, P. O.; Ojeniyi, S. O.; Asawalam, D. O. and Awo, A.O. Root growth, dry root yield and N,P, K content of cassava as influenced by Oil palm bunch ash on ultisols of South west Nigeria. Nigerian Journal of Soil science, 2009b: 19, 6 – 10.

Odedina, S. A., Odedina, I. N., Ayeni, S.O., Arowojolu, S. A., Adeyeye, S.D. and Ojeniyi, S. O.(2003): Effects of type of ash on soil fertility, nutrient availability and yield of tomato and pepper. Nigerian Journal of soil science 13, 61 – 67.

Ogunwale, J. O. Olaniyan and M. O. Aduloju (2002): Morphlogical, Physico – chemical and clay mineralogical properties of soils overlaying basement complex rocks in Ilorin East, Nigeria. Moor Journal of Agricultural Research. Vol.3 920: 147 – 154.

Ojeniyi, S. O and Ighomore, H. (2004): Comparative effects of mulches on Soil and Leaf nutrient content and Cassava yield. Nigerian Journal of Soil Science (14). 2004

Ojeniyi, S.O; Adesoye, S.O; Awodun, M. A and Odedina, S. A (2006): Effects of combined Oil palm bunch Refuse ash on Soil and Nutrient composition and yield of Maize. Proceedings of the 30th Annual conference of the Soil Science of Nigeria 5th – 9th December, 2006. University of Agriculture, Makurdi. Pp 177 - 180.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar