COMPARATIVE EFFECTS OF INTEGRATED APPLICATION OF COCOA POD ASH, POULTRY MANURE AND NPK FERTILIZER ON SOIL NITROGEN, ORGANIC CARBON AND PHOSPHORUS CONTENTS – INCUBATION STUDY

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ABSTRACT

Ayeni L.S. and Adeleye, E. O. *2009. Comparative effects of integrated application of cocoa pod ash, poultry manure and NPK fertilizer on soil nitrogen, organic carbon and phosphorus contents – incubation study.* J.Soil.Nature. 3 (2):15-19.

The potential of integrated application of cocoa pod ash (5 and 10 t ha^{-1}), poultry manure (5 and 10 t ha^{-1}) and NPK 20:10:10 fertilizer (100 and 200 kg ha^{-1}) was compared with optimum recommendation (400 kg ha^{-1}) in enhancing soil nitrogen, organic carbon and phosphorus contents in an incubation study in southwest Nigeria. The treatments included eight treatment combinations of cocoa pod ash, poultry manure and NPK20:10:10 fertilizer; control and 400 kg $^{-1}$ of NPK 20:10:10 fertilizer. The treatments were replicated nine times and sampled at 30, 60 and 90 days of incubation for soil nutrient analysis. NPK fertilizer applied at 400 kg ha^{-1} slightly reduced soil pH while treatments combinations of cocoa pod ash, poultry manure and NPK fertilizer at lower levels significantly increased ($p < 0.05$) soil pH. The treatment combination of cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer significantly increased ($p<0.05$) soil OC, N, NO_3-N, NH_4-N, available P at 30 60 and 90 days of incubation when compared with control. The effects of the treatment combinations were more pronounced at 90 days of incubation. NPK 20:10:10 fertilizer applied at 400 kg ha^{-1} had greater initial impact on soil total N, NO_3-N, NH_4-N and P at 30 days. Soil organic carbon, N, NO_3-N increased between 60 and 90 days of incubation while NH_4-N was reduced due to combined application of cocoa pod ash, poultry manure and NPK fertilizer, indicating continuous decomposition of the organic materials and mineralization of organic nutrients. Combined application of cocoa pod ash, poultry manure and NPK fertilizer was more effective in reducing soil acidity, increasing soil N than application of high rate of NPK fertilizer alone. 5 t ha^{-1} of cocoa pod ash should be combined with 5 or 10 t ha^{-1} of poultry manure and with 100 kg ha^{-1} of NPK 20:10:10 fertilizer for enhancing soil N and P status.

Key words: Soil pH, soil nutrients, mineralization, immobilization

INTRODUCTION

Nitrogen is one of the major nutrients needed by crop to complete its vegetative and reproductive cycle. In Nigeria and other tropical countries, research interest has shifted from mineral fertilizers as source of N to utilization of organic wastes. This is due to scarcity, high cost, nutrient imbalance, soil acidity and degradation in soil physical properties associated with continuous use of mineral fertilizers. Hence, the dominant small-scale farmers depend on organic sources of nutrients. However, the use of organic fertilizers is faced with the problems of slow nutrients release, low quality and large quantity of organic fertilizers needed and handling problem. Therefore, integrated application of organic and inorganic fertilizer is advocated and has been supported by research findings (Ayeni, 2008). Poultry manure has been involved in research on integrated plant nutrient supply and has been ascertained to supply necessary nutrients to the soil and plant and enhance crop performance (Ano and Agwu, 2005). Unlike the case with cocoa pod ash, cocoa pod (husk) ash has not been adequately investigated as nutrient sources, and it has not been involved in integrated plant nutrition (Moyin-Jesu 2007, Ayeni *et al*., 2008).

About 800,000 tones of cocoa pod husk are generated annually in Nigeria and often wasted (Egunjobi 1976). It is advised that the husk be burnt into ash as a method of farm sanitation and for the control of black pod disease. The husk left on the farm harbors the fungus (*phytophtora palmivora*), which is the causal organism of black pod disease. Schumann and Summer (1999) recommended the combined formulations of fly ash, sewage sludge and poultry manure for soil fertility management. There is scarce information on combined formulations that involved cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer on soil nutrients release in southwest Nigeria. Hence, this work aimed at studying the effect of combined use of cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer on soil nutrient release.

MATERIALS AND METHODS

Soil Analysis

Soil samples collected were bulked, air-dried and sieved through 2mm sieved mesh. Part of the soil samples was used for routine soil analysis and laboratory incubation study.

The pH of the soil was determined in 1:1 soil/water suspension. Analysis of nutrients was done as described by Carter (1993). Organic matter was determined by wet dichromate oxidation method, total N by Kjedahl method, available P by molybdenum colorometry. NO_3-N was extracted with KCl while NH_4-

N was extracted with acetic acids and determined by steam distillation. Exchangeable bases (Ca, K and Mg) were extracted with 1N ammonium acetate. Potassium was read on flame photometer while Ca and Mg were read on AAS. Mechanical soil analysis was carried out according to Buoyoucos (1951) method.

Organic Materials Analysis

Fresh Poultry manure was collected from chicken under battery cage system, air dried under shade for fourteen days. Cocoa pod ash was burnt in open field. This is a simulation of what the farmers used in southwestern Nigeria. It reduces volatilization of the nutrients especially the N content. The nutrient composition of powdered poultry manure and cocoa husk ash were determined after ashing in the muffle furnace. Digestion was done with mixture of nitric- sulphuric- perchloric acid for the extraction of P, K, Ca and Mg (Association of Official Analytical Chemists, 1990). Total N was extracted with sulphuric acid in the presence of selenium catalyst and the analysis of these nutrients were carried out as previously described in soil analysis

Incubation Study

A laboratory incubation study to determine the interactions of cocoa pod ash, poultry manure, NPK 20:10:10 and their various combinations with soil constituents at 30, 60 and 90 days were carried out in Ondo ($07^0\ 05^1$N, $04^0\ 55^1$N) in the rainforest zone of southwest Nigeria in early March 2005. The bulked soil samples were transferred to the Soil Science laboratory of the Federal University of Technology, Akure for chemical analysis.

Equal levels of cocoa pod ash and poultry manure at 0.25 and 0.5g/100g soil to represent 5 and 10 t ha^{-1} and two levels of NPK 20:10:10 at 0.05 and 0.1g/100g soil to represent 100 and 200 kg ha^{-1} were formulated as treatments to give eight treatment combinations. Another pot was filled with 100g of soil to contain 0.02g of NPK 20: 10:10 fertilizer to supply the recommended rate of 80 kg N ha^{-1}, 30 kg P ha^{-1} and 30 kg K ha^{-1} (C0P0F400) (ADP, 2005, Adediran *et al.*, 2005) and one plastic cup without any amendment to serve as control (C0P0F0). There were ten treatments in all replicated nine times. Poultry manure, cocoa husk ash, NPK 20: 10:10 and their combinations were thoroughly mixed with their respective soils. The samples were arranged on a flat platform in the laboratory in a completely randomized design. The treatments were watered with equal amount of distilled water weekly.

The nutrients determined were organic matter, NH_4-N, NO_3-N, available P and pH. Destructive analytical method was used. Thirty samples were removed from the ninety samples per month, analyzed and discarded after each analysis. The nutrients stated above were analyzed as described in the soil routine analysis.

RESULT AND DISCUSSION

The sandy clay soil used for the experiment had 1.31% OM, 0.06%total N, 4.9mg kg^{-1} available P, 0.16cmol kg^{-1} K, 2.31 cmol kg^{-1} Ca, 0.20 cmol kg^{-1} Mg and 5.8 pH. This indicated that the soil used for the study was deficient in soil organic matter, N, NO_3-N, P, K and Mg but adequate in Ca. Compared with 3% for organic matter, 0.15% for total N, 30 mg kg^{-1} for NO_3-N, 8 – 10 mg kg^{-1} for available P, 2.0 cmol kg^{-1} for exchangeable Ca and 0.24 cmol kg^{-1} for Mg recommended for southwest Nigeria (Sobulo and Osiname, 1987, Adetunji, 1991).

Poultry manure is higher in nutrient values than cocoa pod ash in respect to N, P and Mg while cocoa pod ash is higher in K and Ca (Table 1). Poultry manure and cocoa pod ash composition in this experiment is in line with the work of Ayeni *et al*, (2008a and 2008b) and Ayeni, (2008), that poultry manure is richer in N, P and micronutrients than cocoa pod ash while cocoa pod ash is richer in K, Ca and Mg.

Table 1. Nutrient composition of cocoa pod ash and poultry manure used in the experiment (%)

Nutrient	OM	N	C/N	P	K	Ca	Mg
Poultry Manure	21.70	3.70	6	2.72	5.91	2.80	8.00
Cocoa pod ash	16.56	1.23	14	1.10	12.52	3.74	2.40

Application of combined cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer increased soil pH relative to control at 30, 60 and 90 days of incubation (Table 2). The pH was highest irrespective day of incubation when higher level of cocoa pod ash (10 t ha^{-1}) was included in the treatment formulation. The highest pH was given by C5P10F100 at 30 days and C10P10F100 at 60 and 90 days of incubation. It is indicated that cocoa pod ash is a suitable liming material due to the supply of base elements. This finding is in agreement with Odedina *et al*. (2003). The pH of the control (C0P0F0) and 400 kg ha^{-1} NPK 20:10:10 fertilizer (C0P0F400) were not significantly different ($p<0.05$) throughout the 90 days of incubation

whereas the pH of the combined cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer at all rates were statistically higher than 400 kg ha^{-1} NPK 20:10:10 fertilizer and the control. This indicates that addition of combined cocoa pod ash and poultry manure obliterated the acidic effect of NPK 20:10:10 fertilizer by raising the soil pH in the soil samples that contained the three fertilizer materials.

Application of combined cocoa pod ash, poultry manure and NPK 20:10:10 increased soil organic carbon relative to control and NPK fertilizer at 30, 60 and 90 days (Table 2).There was no consistent relationship between soil organic carbon and the numbers of days of incubation. Treatment C10P10F200 had the highest organic carbon at 30 days while C5P10F200 had the highest soil organic carbon at 60 and 90 days. It is indicated that combined cocoa pod ash, poultry manure and NPK fertilizer contributed organic carbon to the soil while 400 kg ha^{-1} NPK 20:10:10 fertilizer did not increase organic carbon appreciably relative to control. This indicates that the organic materials combined with NPK fertilizer continuously decomposed during this period and added organic matter to the soil and has better residual effect on the soil. Cocoa pod ash used in this experiment contained organic carbon as a result of incomplete burning.

Table 2. Effect of combined cocoas pod ash, poultry manure and NPK 20:10:10 on soil nutrients within 90 days of incubation

30 days Treatment	**pH**	**OC**	**N**	**NO_3-N**	**NH_4-N**	**P**
		%		**mg kg^{-1}**		
C0P0F0	5.82c	0.09c	0.09d	28.26g	25.62d	4.19d
C0P0F400	5.88c	1.12c	0.39a	280.18a	349.34a	27.25a
C5P5F100	6.68b	2.29a	0.20b	49.35f	310.62a	10.10c
C5P5F200	6.42b	1.45b	0.32a	212.43b	323.22a	10.25c
C5P10F100	6.49b	1.48b	0.36a	111.86e	319.31a	13.69c
C5P10F200	6.43b	1.48b	0.37a	163.16c	121.22c	16.32b
C10P5F100	7.18a	2.05a	0.18c	94.59f	123.40c	11.31c
C10P5F200	6.84ab	1.63b	0.14c	113.00e	163.70b	6.30d
C10P10F100	7.16a	2.31a	0.20b	121.69d	310.11a	34.60a
C10P10F200	7.06a	2.50a	0.22b	130.68a	334.60a	15.86b
60 days						
C0P0F0	5.84e	1.10c	0.10b	32.10d	17.35d	4.89d
C0P0F400	5.86e	1.15c	0.22a	219.49b	39.05c	10.10c
C5P5F100	6.64c	2.30a	0.21a	148.20c	97.30a	10.08c
C5P5F200	6.39c	2.00b	0.19a	204.26b	92.12a	10.23c
C5P10F100	6.03d	1.78b	0.19a	272.88a	34.10c	14.01b
C5P10F200	6.19c	2.35a	0.21a	283.88a	52.07b	16.29b
C10P5F100	7.96a	1.67bc	0.13b	131.35c	34.90c	6.30d
C10P5F200	7.90a	1.71b	0.15b	114.78cd	37.50c	6.29d
C10P10F100	7.10a	1.74b	0.16ab	236.94ab	72.23a	20.30
C10P10F200	7.03b	1.88b	0.17a	256.00a	86.10a	15.83b
90 days						
C0P0F0	5.99b	1.07b	0.10b	38.76c	2.27e	4.99d
C0P0F400	5.99b	1.18b	0.17b	120.82b	3.47e	10.00c
C5P5F100	6.53c	2.39a	0.21a	395.72a	13.21d	10.91c
C5P5F200	6.30a	2.26a	0.20a	367.04a	13.13d	11.05c
C5P10F100	0.6.03b	2.21a	0.20a	479.55a	18.09b	14.19b
C5P10F200	6.18b	2.61a	0.22a	436.25a	20.49b	17.63a
C10P5F100	6.92a	2.10a	0.18ab	159.71b	11.33c	12.22c
C10P5F200	6.06b	2.43a	0.22a	299.80b	12.49c	6.81d
C10P10F100	6.99a	2.21a	0.19a	419.47a	22.32b	21.97a
C10P10F200	6.59a	2.50a	0.22a	447.43a	30.12a	17.13a

Columns with the same letters are not significantly different at 5% level with Duncan multiple range test

Application of combined cocoa pod ash, poultry manure, NPK 20:10:10 fertilizer increased soil total N relative to control. NPK fertilizer applied alone increased total N between 30 and 60 days of incubation and lower N at 90 days compared with all the treatment combinations. The treatments that included 10 t ha^{-1} of cocoa pod ash in the formulation with lower level of poultry manure (C10P5F100 and C10P5F200) had lower total N than when 5 t ha^{-1} cocoa pod ash was used (C5P5F100, C5P5F200, C5P10F100 and C5P10F200).This shows that poultry manure plays prominent role in supplying N in the treatment combinations in this study. Generally, the increase in N with the number of days of incubation in the triple combinations indicated that more N is being released gradually into the soil with time because of higher C/N ratio of cocoa pod ash and poultry manure than NPK 20:10:10 fertilizer applied at 400 kg ha^{-1}. The gradual reduction in total N experienced by C0P0F400 as the period of incubation progressed might be as a result of quick release of N due to rapid rate of mineralization of the mineral fertilizer attributed to its low C/N ratio which might have resulted into the loss NH_3 over time.

Combined cocoa pod ash, poultry manure and NPK fertilizer significantly increased ($p<0.05$) soil NO_3-N compared with control. C0P0F400 had the highest value of NO_3-N at 30 days and tended to decrease as the period of incubation increased while the combined fertilizer materials increased as the period of incubation progressed. The low NO_3-N experienced by the combined fertilizer materials at the first month of incubation could be due to initial immobilization of NO_3-N by the microbes degrading the combined cocoa pod ash and poultry manure which had higher C/N ratio than NPK fertilizer as experienced in case of total N. Comparison between the treatments that had 5 t ha^{-1} cocoa pod ash and 10 t ha^{-1} cocoa pod ash in the formulations showed that 5 t ha^{-1} cocoa pod ash seemed to enhanced mineralization of total N, and NO_3-N than its corresponding 10 t ha^{-1}. This might be as a result of the bulkiness of 10 t ha^{-1} of cocoa pod ash, which became more difficult for the microbes to break down and thereby resulted in partial immobilization.

Relative to control, all the combinations increased NH_4-N. All the treatments decreased as the period of incubation increased. This might be as a result of conversion of NH_4-N to NO_3-N (oxidation) by microbes since NH_4-N is the first product of conversion of organic N to inorganic N. Even C0P0F400 and C0P0F0 were not significantly different ($p < 0.05$) at 90 days of incubation. The same observation was made by Whalen *et al*. (2000); that NH_4-N reduced drastically after 8 week of incubation of poultry manure of Beaverlodge soil.

Compared with control, combined cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer increased soil available P. Treatments C10P5F100 and C5P10F200 had low available P between 30 and 60 days. The two treatments had appreciable P at 90 days. The low available P between 30 and 60 days might have resulted in complexation between P and Ca at high pH, which rendered P unavailable. C10P10F100 gave the highest available P value at 30 days while C10P10F100 gave highest P between 60 and 90 days.

The findings that experimental soil was low in soil OM, N, P, K, Mg and slightly acidic, justify the need for experimenting with poultry manure and cocoa pod ash as source of additional nutrients. The low soil fertility status might have caused the higher release of nutrients from the organic materials used as treatments than the soil sample without treatment. The two organic materials had varying OC, N, P, Ca and Mg. The two materials released nutrients to the soil and complement each other in balanced supply of nutrients to soil. NPK 20:10:10 fertilizer at 100 and 200 kg ha^{-1} included in the formulation might have shortened the period of immobilization and enhanced quicker mineralization of nutrients from the two organic materials. The N and P present in the mineral fertilizer might also complement the nutrients from cocoa pod ash and poultry manure between 30 and 90 days.

Compare with the control and NPK fertilizer, the combinations increased soil pH. The mechanism given by Ano and Ubochi (2007) was the microbial decarbozylation of Ca-organo complex leading to release and consequent hydrolysis of Ca ions. The hydroxyl ions released react with exchangeable H^+ and Al^{3+} to form water and insoluble $Al(OH)_3$ respectively. Therefore, the organic materials tested in this study had liming effect. C0P0F400 increased soil OC, N, NO_3-N, NH_4-N and available P at 30 days but all the treatment combinations had their effects between 60 and 90 days. NPK20: 10:10 fertilizer was a quicker source of N and P. Aside from complementing organic materials in releasing N, and P to the soil; it also enhanced decomposition and mineralization of organic nutrients due to microbial activities (Olayinka and Adebayo, 1983). The finding that soil organic matter, N, NO_3-N and P increased between 60 and 90 days for the combined treatments suggested that the materials were still decomposing and nutrients mineralized up to 90 days of incubation.

CONCLUSION

Integrated application of organic and inorganic fertilizer ensured more balanced and complete release of nutrients compared with the use of NPK 20:10:10 fertilizer alone. Lower level of cocoa pod ash is advocated to be included in the formulation as it ensures more balanced plant nutrition.

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