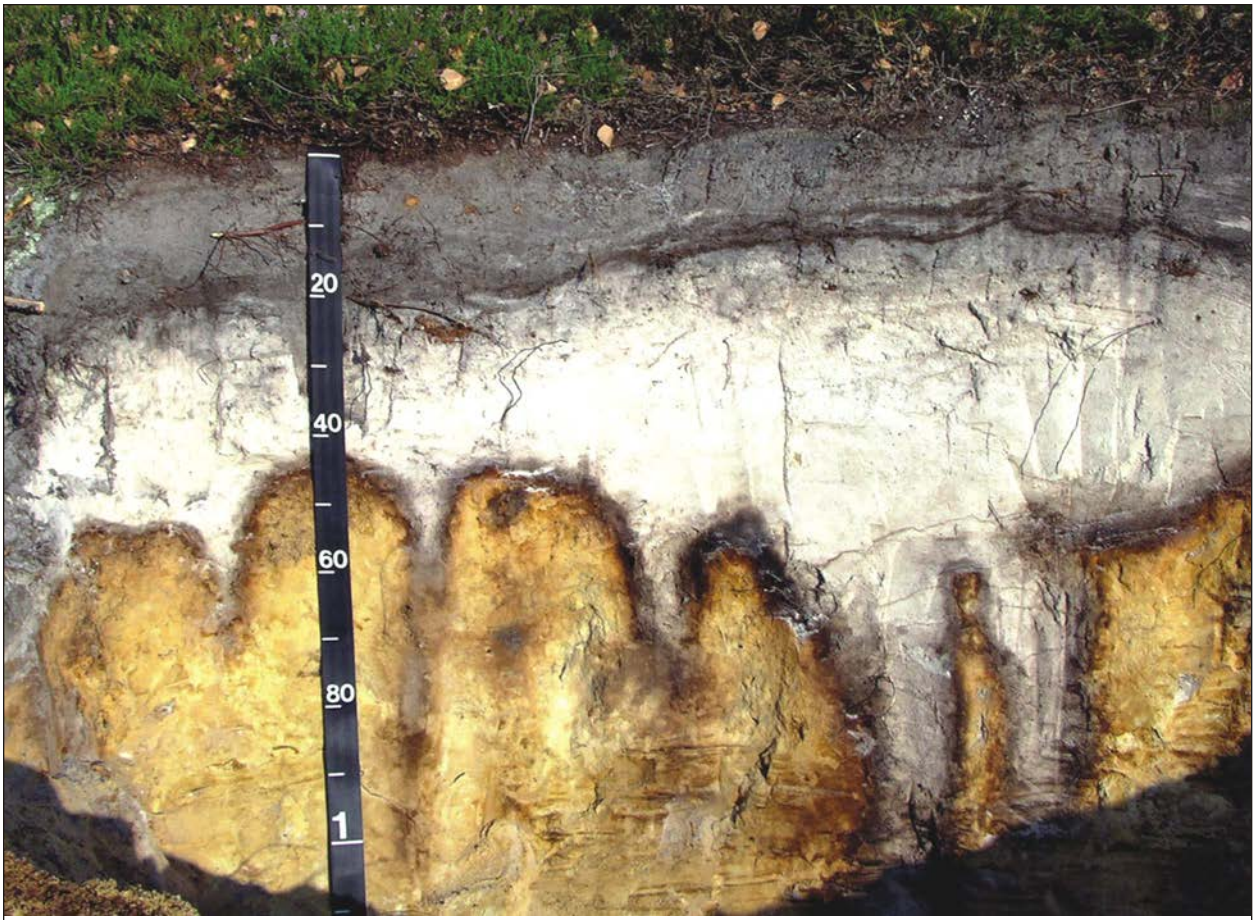

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Soil Nutrient Status and Nutrient Interactions as Influenced by Agro Wastes and Mineral Fertilizer in an Incubation Study in the South West Nigeria

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ABSTRACT

The objective of this study was to compare the effects of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on soil nutrient status as well as their interactions. The study was conducted in South Western Nigeria. Two levels of cocoa pod ash at 5 and 10 t ha^{-1}; poultry manure at 5 and 10 t ha^{-1} and NPK 20:10:10 fertilizer at 100 and 200 kg ha^{-1} were separately mixed with soil constituents. There was a control without any treatment. The treatments were replicated nine times on completely randomized design and were sampled at 30, 60 and 90 days for analysis. Three samples per treatment were analysed and discarded each month. Cocoa pod ash and poultry manure rates significantly increased ($p<0.05$) soil pH, organic matter, N, Ca, Mg, CEC and percent base saturation. Cocoa pod ash at 10 t ha^{-1} recorded the highest pH and Ca at 30, 60 and 90 days. NPK fertilizer at 200 kg ha^{-1} had the highest N, P and exchangeable acidity at 30, 60 and 90 days. Cocoa pod ash applied at 10 t ha^{-1} had highest CEC at 60 days of incubation. Cocoa pod ash and poultry manure decreased exchangeable acidity, while NPK rates increased it. Cocoa pod ash at 10 t ha^{-1} had the widest Ca: Mg ratio among the treatments and thus may be prone to nutrient antagonism. Cocoa pod ash and poultry manure rates reduced K: Ca ratio compared with control. Among the treatments, OC: N, Ca: Mg and K: Ca ratios fall within the acceptable range for arable crop production in Southwestern Nigeria.

Key words: CEC, exchange acidity, percent base saturation, NPK

INTRODUCTION

Chemical properties of soil play significant role in crop production. A soil that supplies adequate Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S) and micronutrients with favourable soil pH will produce plant of vigour and good yield if other conditions of growth such as biological and physical properties of soil are favourable (Anderson,1991). Soils are not just to supply adequate nutrients alone but the nutrients to be in proper balance. Phosphorus is known to help in root growth, seed formation and quick ripening of fruits while Ca helps in pectate formation and tuberization (Anonymous, 1993). Calcium may antagonize available P if they are not in balanced proportion. Though, N helps in chlorophyll formation and plant growth, its excess in relation to other nutrients, such as P, K and S can delay crop maturity. Also, Na and K have negative interactions. Changes in soil pH will result in numerous interactions where one ion or nutrient interferes with or competes with the uptake and utilization of other nutrients by plants.

Studies have shown the effectiveness of cocoa pod ash, poultry manure and mineral fertilizer in the release of nutrients for crop production in Southwestern Nigeria (Ayeni *et al.*, 2008; Ayeni, 2010; Akanni and Ojeniyi, 2007). Cocoa pod is derived from *Theobroma cacao* popularly grown for its chocolate flavour. Its pod husks are burnt purposely for the control of black pod disease. Its ash has also been tested in farmers' field as source of plant nutrients. About 800,000 metric tonnes of cocoa pod is found lying fallow in farmers' field in southwestern Nigeria (Egunjobi, 1975). Poultry manure is also a cheap source of plant nutrients (Mbagwu, 1992; Mba, 2006; Mbah and. Mbagwu, 2006). Huge amount of poultry dung are found being dumped in urban cities of Nigeria which constitutes health hazard. Its use as farm manure has helped to reduce environmental pollution. Peasant farmers in Southwestern Nigeria have noted the impact of mineral fertilizers on crop yields but have been using them without soil test. It is necessary to study the rate at which NPK fertilizer, cocoa pod ash and poultry manure release N, P, K Ca and Mg to the soil for crop production. Hence, the objective of this study was to compare the effects of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on soil nutrient status and some other soil fertility variables.

MATERIALS AND METHODS

Soil and organic wastes analysis: Laboratory incubation study was carried from March-May 2009 to determine the effects of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on soil nutrient status as well as their interactions on Alfisol in southwestern Nigeria. Soil samples were collected from the field at 0-20 cm depth, air-dried and sieved through 2 mm sieved mesh. Part of the soil samples was used for routine soil analysis and the remaining soil sample was used for laboratory incubation study.

The pH of the soil was determined in 2:1 $CaCl_2$/soil suspension using a glass electrode pH meter. Organic matter was determined by the Walkley and Black (1934) dichromate oxidation method. The percentage organic matter was calculated by multiplying the values of organic carbon by the conventional Van Bemmeller factor of 1.724 based on the assumption that soil organic matter contains 58% carbon (Allison, 1982). Total N was determined by the Kjedahl method (Jackson, 1962). Available phosphorus was extracted by 0.03 M NH4F+0.025 M HCl (Bray and Kurtz, 1945) and the P in the extractant was determined by colorimeter. Exchangeable bases (Na, Ca, K and Mg) were extracted with 1 N ammonium acetate at pH 7.0. Potassium and Na were read using flame photometer while Ca and Mg were determined by Perkin Elmer 20 Atomic Absorption Spectrophotometer (AAS) (AOAC, 1990).

The exchangeable acidity was determined from 0.1 M KCl extracts and titrated with 0.1 M HCl (McLean, 1982). Effective Cation Exchange Capacity (ECEC) was established as the summation of the exchangeable cations (K, Ca, Mg and Na).

The nutrient composition of powdered poultry manure and cocoa husk ash were also determined after ashing in the muffle furnace. Total N was determined by Kjedahl method. For other nutrients, ground samples were subjected to wet digestion using 25-5-5 mL of HNO_3-H_2SO_4-$HClO_4$ acids (AOAC, 1990). The filtrate was used for nutrients determination as done in routine soil analysis. Total P was determined by colorimeter, K by flame photometer and Ca, Mg and by AAS.

A laboratory incubation study to determine the interactions of cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer with soil constituents at 90 days was conducted at Adeyemi College of Education and was later transferred to the Federal University of Technology for chemical analysis.

One hundred grammes of soil sample in plastic cup were used for the incubation study. The treatments applied consisted of cocoa pod ash at 0, 0.25 and 0.5 g, poultry manure at 0, 0.25 and 0.5 g to represent 0, 5 and 10 t ha^{-1}, respectively. NPK 20:10:10 fertilizer consisted of 0, 0.05 and 0.1 g to represent 0, 100 and 200 kg ha^{-1}. The treatments were replicated three times. The soil samples were arranged on a flat platform in the laboratory in completely randomized design. The experiment was in the laboratory for 90 days.

RESULTS

The soil used for the conduct of experiment was slightly acidic deficient in OM, N and K (Table 1) considering the critical level of nutrients recommended for arable crops in Southwestern Nigeria (Sobulo and Osiname, 1987). Poultry manure had higher N and P than cocoa pod ash while cocoa pod ash was higher in cations (Table 2).

Compared with control, cocoa pod ash and poultry manure rates significantly increased ($p<0.05$) soil pH at 30 days of incubation (Table 3). Application of NPK 20:10:10 fertilizer had no significant effect on soil pH at 30 days of incubation. Cocoa pod ash applied at 5t ha^{-1} significantly increased soil pH more than 10 t ha^{-1} poultry manure. Also, 10 t ha^{-1} of cocoa pod ash significantly increased ($p<0.05$) soil pH than 10 t ha^{-1} poultry manure. Among the treatments, 10 t ha^{-1} cocoa pod ash recorded the highest pH while 200 kg ha^{-1} NPK 20:10:10 had the lowest soil pH at 30 days of incubation. Compared with control, cocoa pod ash, poultry manure and NPK fertilizers rates significantly increased ($p<0.05$) soil OM and N. NPK fertilizers applied at 200 kg ha^{-1} had the

Table 1: Initial soil properties

Soil properties	Values
pH	5.79
OC	7.6%
OM	13.1%
N	0.6%
P	5.27 mg kg^{-1}
K	0.16 c mol kg^{-1}
Ca	2.32 c mol kg^{-1}
Mg	0.20 c mol kg^{-1}
Na	0.37 c mol kg^{-1}
EA	1.36 c mol kg^{-1}
CEC	3.05 c mol kg^{-1}
ECEC	4.41 c mol kg^{-1}
%BS	69
CN	1:13
Kmg	1:15

Table 2: Nutrient concentration of poultry manure and cocoa pod ash (%)

Agro wastes	Poultry manure (PM)	Cocoa pod ash (CPA)
OC	21.70	16.65
N	3.70	1.23
P	4.77	2.10
K	3.51	4.46
Ca	2.89	5.40
Mg	0.72	1.11

Table 3: Effect of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on soil chemical properties 30 days after application

Treatments	pH	OM	N	P	K	Ca	Mg	Na	EA	CEC	ECEC	%BS
		--------(%)--------		(mg kg^{-1})	---------------------------------(c mol kg^{-1})-----------------------------------							
Control	5.82	1.80	0.09	3.90	0.13	2.65	1.27	0.25	2.05	4.50	6.55	68
100 kg ha^{-1} NPK	5.62	1.86	0.13	7.97	0.13	2.65	1.14	0.35	2.06	4.27	6.33	68
200 kg ha^{-1} NPK	5.44	1.90	0.19	5.00	0.23	2.63	1.03	0.36	2.08	4.05	6.13	66
5 t ha^{-1} CPA	6.05	2.10	0.13	7.60	0.25	3.94	1.40	0.54	1.24	6.13	7.37	83
10 t ha^{-1} CPA	6.94	2.41	0.13	8.20	0.58	5.40	0.70	0.60	1.21	7.24	8.35	86
5 t ha^{-1} PM	6.35	2.45	0.13	7.20	0.14	3.50	1.67	0.56	1.31	5.87	7.18	98
10 t ha^{-1} PM	6.35	2.48	0.13	12.20	0.20	3.60	1.20	0.63	1.28	5.63	6.91	80
LSD (0.05)	0.30	0.08	0.04	2.20	0.11	1.10	0.50	0.20	0.50	2.10	1.00	-

NPK: NPK 20:10:10 fertilizer, CPA: Cocoa pod ash, PM: Poultry manure

highest OM and N while the control experiment recorded the lowest OM and N. all the treatments significantly increased soil P compared with control. Poultry manure at 10 t ha^{-1} had higher P than 5 t ha^{-1} poultry manure. NPK 20:10:10 fertilizer applied at 200 kg ha^{-1} recorded the highest P while 5 t ha^{-1} cocoa pod ash recorded the lowest P. Poultry manure applied at 10 t ha^{-1} significantly increased soil phosphorus compared with 10 t ha^{-1} of cocoa pod ash at 30 days of incubation. All the treatments significantly increased K except 100 kg ha^{-1} NPK fertilizer compared with control.

Cocoa pod ash at 10 t ha^{-1} supplied more K than 5 t ha^{-1} cocoa pod ash; 5 t ha^{-1} cocoa pod ash had higher soil K than 5 t ha^{-1} poultry manure, 10 t ha^{-1} cocoa pod ash was higher in soil K than 10 t ha^{-1} poultry manure. Cocoa pod ash applied at 10 t ha^{-1} supplied the highest K while, 100 kg ha^{-1} NPK fertilizer and the control experiment recorded the lowest K. Cocoa pod ash applied at 10 t ha^{-1} significantly in creased soil Ca than 5 t ha^{-1} cocoa pod ash and 10 t ha^{-1} poultry manure. Cocoa pod ash applied at 10 t ha^{-1} had highest Ca while 200 kg ha^{-1} NPK fertilizer had the lowest Ca. poultry manure at 5 t ha^{-1} had the highest Mg, while, 10 t ha^{-1} cocoa pod as reduced Mg. All the treatments significantly increased Na except NPK fertilizer rates. Cocoa pod ash rates and poultry manure rates significantly reduced exchangeable acidity while NPK fertilizer rates had n significant effect at 30 days of incubation. At 30 days of incubation cocoa pod ash and poultry manure rates significantly increased soil Cation Exchange Capacity (CEC). Cocoa pod ash applied at 10 t ha^{-1} recorded the highest CEC while 200 kg ha^{-1} of NPK 20:10:10 had the lowest CEC. Compared with control cocoa pod ash rates and 5 t ha^{-1} poultry manure significantly increased the ECEC of the soil cocoa pod ash at 10 t ha^{-1} the highest ECEC while NPK fertilizer at 200 kg ha^{-1} had the lowest ECE.

At 60 days of incubation, all the treatments except NPK fertilizer rates significantly increased ($p<0.05$) soil pH. Cocoa pod ash applied at 10 t ha^{-1} had highest soil NPK fertilizers at 200 kg ha^{-1} had the lowest soil pH rates (Table 4). Cocoa pod ash and poultry manure rates significantly increased soil pH over NPK fertilizer rates and control. Only poultry manure rates significantly increased soil organic matter and N at 60 days of incubation. Relative to control, all the treatments significantly increased soil P. NPK fertilizer at 200 kg ha^{-1} recorded the highest P followed by 10 t ha^{-1} poultry manure. At 60 days, 10 t ha^{-1} poultry manure significantly increased P over 5 t ha^{-1} poultry manure. Compared with control cocoa pod ash and poultry manure rates significantly increased soil Ca. 10 t ha^{-1} cocoa pod ash was significantly (p<o.05) higher than 10 t ha^{-1} poultry manure in Ca. 10 t ha^{-1} cocoa pod ash recorded the highest increase in Ca. Though increases in Mg was not significantly, among the treatments, 5 t ha^{-1} poultry manure recorded the highest Mg while 10 t ha^{-1} cocoa pod ash recorded the lowest Mg at 60 days of incubation. Cocoa pod ash and poultry manure rates had significant effect on soil Na compared

Table 4: Effect of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on soil chemical properties 60 days after application

		OM	N	P	K	Ca	Mg	Na	EA	CEC	ECEC	
Treatments	pH	--------(%)--------		(mg kg^{-1})	---------------------------------(c mol kg^{-1})-----------------------------------							%BS
Control	5.84	1.90	0.10	490	0.99	2.67	1.29	0.50	2.04	4.65	6.69	70
100 kg ha^{-1} NPK	5.59	1.90	0.13	7.96	0.22	2.66	1.03	0.43	2.08	4.34	6.42	70
200 kg ha^{-1} NPK	5.40	2.00	0.20	19.63	0.27	2.61	1.04	0.45	2.09	4.47	6.56	68
5 t ha^{-1} CPA	6.07	2.90	0.14	7.70	0.60	3.00	1.20	1.30	1.10	6.19	7.29	85
10 t ha^{-1} CPA	6.99	2.76	0.14	8.56	0.70	5.70	1.00	1.32	1.32	7.72	9.04	97
5 t ha^{-1} PM	6.32	3.38	0.17	7.53	0.56	3.20	1.70	1.36	1.30	6.82	8.12	96
10 t ha^{-1} PM	6.47	3.41	0.20	12.91	0.59	4.00	1.40	2.00	0.94	7.99	8.93	81
LSD (0.05)	0.32	0.10	0.02	2.60	0.12	1.25	Ns	0.22	0.50	2.0	1.12	-

NPK: NPK 20:10:10 fertilizer, CPA: Cocoa pod ash, PM: Poultry manure

Table 5: Effect of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on soil chemical properties 90 days after application

		OM	N	P	K	Ca	Mg	Na	EA	CEC	ECEC	
Treatments	pH	--------(%)--------		(mg kg^{-1})	---------------------------------(c mol kg^{-1})-----------------------------------							%BS
Control	5.99	1.90	0.10	5.00	0.20	2.69	1.40	0.55	2.12	4.84	6.69	6.96
100 kg ha^{-1} NPK	5.56	1.93	0.14	7.45	0.22	2.66	1.44	0.32	2.15	5.64	6.42	7.79
200 kg ha^{-1} NPK	5.40	2.00	0.20	19.43	0.47	2.60	1.40	0.43	2.40	4.90	6.56	7.30
5 t ha^{-1} CPA	6.15	2.96	0.14	7.95	0.63	3.27	1.00	1.10	1.00	6.00	7.29	7.00
10 t ha^{-1} CPA	7.29	2.64	0.15	12.00	0.87	6.21	1.00	1.40	0.90	10.03	9.04	10.93
5 t ha^{-1} PM	6.34	3.97	0.19	8.00	0.58	3.68	1.32	1.30	1.30	6.88	8.12	8.18
10 t ha^{-1} PM	6.49	4.66	0.28	18.99	0.64	4.40	1.20	2.06	1.01	8.30	8.93	9.31
LSD (0.05)	0.30	0.12	0.08	2.80	0.15	1.22	0.51	0.17	0.52	2.00	1.12	1.20

NPK: NPK 20:10:10 fertilizer, CPA: Cocoa pod ash, PM: Poultry manure

with control. Cocoa pod ash and poultry manure rates significantly reduced exchange acidity compared with control. The NPK fertilizer at 200 kg ha^{-1} had the highest EA while poultry manure at 10 t ha^{-1} had the lowest EA 60 days after incubation. Cocoa pod ash and poultry manure rates significantly increased CEC compared with control. Poultry manure at 10 t ha^{-1} recorded the highest CEC while 100 kg ha^{-1} had the lowest CEC. Also, cocoa pod and poultry manure at all levels significantly increased ECEC except 5 t ha^{-1} cocoa pod ash. Cocoa pod ash at 10 t ha^{-1} had the highest ECEC while 100 kg ha^{-1} NPK fertilizer had the lowest ECEC.

At 90 days of incubation, cocoa pod ash and poultry manure rates significantly increased soil pH (Table 5). The NPK fertilizer tended to reduce soil pH at 90 days of incubation. Cocoa pod ash at 10 t ha^{-1} had more effect on soil pH than other treatments. Relative to control and NPK fertilizer, cocoa pod ash and poultry manure rates significantly increased ($p<0.05$) soil OM and N. All the treatments had higher P. At 90 days, Ca was more pronounced in soils treated with cocoa pod ash and poultry manure than NPK fertilizer rates and control. Cocoa pod ash applied at 10 t ha^{-1} most enhanced soil Ca. cocoa pod ash and poultry manure rates seemed to reduce soil Mg at 90 days of incubation. All the treatments significantly increased soil Na except NPK fertilizer rates over control. Cocoa pod ash and poultry manure tended to reduce soil exchangeable acidity compared with control and NPK fertilizer compared with control, cocoa pod ash and poultry manure rates significantly increased CEC. Cocoa pod ash at 10 t ha^{-1} recorded the highest CEC at 90 days of incubation. Cocoa pod ash at 10 t ha^{-1} recorded the highest ECEC followed by poultry manure at 10 t ha^{-1}.

The mean C/N ratio for 30, 60 and 90 days of incubation period showed 200 kg ha^{-1} NPK fertilizer with soil constituents recorded the lowest C/N ratio while 10 t ha^{-1} had the highest C/N

Table 6: Effects of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure on some soil nutrient ratios

Treatments	C/N	K/Mg	Mg/Ca	K/Ca
Control	12	8	1.4	16
100 kg ha^{-1} NPK	8	7	2.2	15
200 kg ha^{-1} NPK	6	5	2.3	9
5 t ha^{-1} CPA	12	3	3.0	9
10 t ha^{-1} CPA	13	2	7.0	8
5 t ha^{-1} PM	11	6	2.3	12
10 t ha^{-1} PM	11	3	3.2	11

NPK: NPK 20:10:10 fertilizer, CPA: Cocoa pod ash, PM: Poultry manure

ratio. Control experiment had the highest K/Mg ratio while 10 t ha^{-1} cocoa pod had least K/Mg ratio (Table 6). Cocoa pod ash applied at 10 t ha^{-1} had the widest Mg/Ca ratio as against control which was lowest among the treatments. Control experiment recorded the highest K/Ca ration while cocoa pod ash at 10 t ha^{-1} recorded the lowest K/Ca ratio.

DISCUSSION

The low fertility status of the soil used for the experiment shows that the soil needs fertilization. There were increases in the pH of the soils amended with cocoa pod ash and poultry manure. Whalen *et al.* (2000) have reported a similar effect on soil pH after application of animal manure. The higher soil pH in cocoa pod ash and poultry manure amended soils may have been partially although, not totally due to Ca contents as the rate of increase in pH was proportional to increase in Ca Calcium carbonate and organic acids in the agrowastes (cocoa pod ash poultry manure) may collectively butter soil acidity (Whalen *et al.*, 2000) and the hydrolysis of Na released from exchange sites or solubilized from the agrowastes can also increase soil pH. The decreases experienced in pH of the soils treated with NPK 20:10:10 fertilizer might be due to the acidic nature of the mineral fertilizer.

The persistent increase in organic matter and N might be as a result of mineralization. Incubation of NPK 20:10:10 fertilizer, cocoa pod ash and poultry manure amended soils produced net increases in the mineral N pool, which suggests conditions were favouable for microbial growth and their activities in soils. The continuous increase in soil N and P by cocoa pod ash and poultry manure throughout the incubation period showed that much of N and P added in the agrowastes remain in a pool that is readily available for plant uptake and that mineralization has not stopped at 90 days of incubation. The higher amount of N and P released by NPK fertilizer over cocoa pod ash and poultry manure suggests that mineralization was fasters in the mineral fertilizer than the agrowastes during the incubation period. This might as a result of rapid solubility of NPK in soil solution. Though, C/N ratio plays significant role in N and P mineralization, the rapid mineralization of nutrients in soils fertilized with NPK 20:10:10 over the agrowastes could not be adduced to C/N ratio because the C/N ratios of cocoa pod ash and poultry manure still fall within the acceptable range for N and P mineralization. Bernard *et al.* (2005) suggest that a C/N ratio greater than 30 and a C/N ratio greater than 300 generally cause soil N and P immobilization. For 5 t ha^{-1} cocoa pod ash, N mineralization stopped at 60 days while mineralization proceeded to 90 days with 10 t ha^{-1} cocoa pod ash. This suggests exhaustible release of N present in 5 t ha^{-1} cocoa pod ash. The gradual release of N and P by the organic wastes especially at 10 t ha^{-1} suggests that the N and P will not be easily prone to leaching and will be more available to crops that have their vegetative and reproductive cycle beyond 90 days. Split application of NPK fertilizers that is being practiced by local farmers in Nigeria due to fear of nutrient leaching may not be necessary if cocoa pod ash or poultry manure is used as fertilizer since the nutrients are gradually being released.

The higher K/Ca, Na and Mg recorded by organic wastes over NPK fertilizer suggests the superiority of cocoa pod ash and poultry manure in supplying cations (except K) to the soil which acts as liming materials that is not included in NPK 20:10:10 formulation. The reduction in Exchangeable Acidity (EA) in soils amended with agrowastes and the consequent increase in EA in soils fertilized with NPK 20:10:10 in this experiment suggests the ability of these organic wastes in lowering soil Al^{3+} and H^{2+} concentration. Cocoa pod ash released more K and Ca to soil than poultry manure. This is expected because the chemical composition of cocoa pod ash shows that it contains more K and Ca than poultry manure. The higher release of K and Ca by cocoa pod ash suggests that it will be more useful in correcting soil acidity than poultry manure if judiciously applied. Both cocoa pod ash and poultry manure especially at 10 t ha^{-1} supplied adequate K, Ca and Mg for plant use (Sobulo, 1990). Therefore, these cations will not constitute a yield limiting factor if these agrowastes are properly applied to give positive interactions. An interaction occurs when the level of one production factor influences the response of other factors. A positive interaction occurs when the influence of the combined practices exceeds the sum of the influences of the individual practices (Anonymous, 1993).

Cocoa pod ash and poultry manure Ca/Mg ratios fall within the acceptable range 1:30 (Adepetu *et al.*, 1979) with which soil condition is usually not expected to produce Mg deficiency in plants. Adetunji (1991) suggests a Ca/Mg ratio of 1:2 as the best soil condition that will not produce Mg deficiency in plants. According to Adetunji (1991) assertion, 10t ha^{-1} cocoa pod ash (Ca/Mg, 1:7) may cause Mg deficiency as the Mg released was too low compared with other treatments. Ayeni (2009) in South Western Nigeria noted higher yield of maize in soils amended with 5 t ha^{-1} cocoa pod ash than its corresponding 10 t ha^{-1}, he attributed it to nutrient imbalance in South Western Nigeria. Potassium is known to antagonize Ca. Cocoa pod ash and poultry manure were able to reduce K/Ca ratio when they were mixed with soil constituents in this experiment. It is also noted that K/Ca ratio was substantially decreased when 200 g ha^{-1} NPK fertilizer was added to the soil as against high K/Ca ratio in control experiment and 100 g ha^{-1} NPK fertilizer. This shows that the soil needs additional potassium fertilizer to reduce the K/Ca ratio to make the nutrients balance for plant uptake.

Cocoa pod ash applied at 10 t ha^{-1} recorded the highest CEC especially at 90 days of incubation. The CEC, though low, is not usual for highly weathered tropical soils with relatively low content organic matter (Sobulo, 1990). The higher CEC recorded by the treatments over the control indicates that cocoa pod ash, poultry manure and NPK fertilizer can improve fertility status of the soil.

Cocoa pod ash and poultry manure had higher percent base saturation (%BS) than the control and NPK fertilizer. Generally, initial soil characteristics and control experiment showed that the %BS of the soil was greater than 50%. High base status like this soil, is almost synonymous with high native soil fertility and relatively low cost of supplying additional nutrients. Cocoa pod ash and poultry manure in this research had significantly increased the %BS of the soil. Sanchez and Salians (1981) have suggested that tropical soils of this nature should be managed with the aim of maximizing the potential of high yielding crop varieties and improving the cropping system with intensive fertilizer input. Cocoa pod ash and poultry manure at high rates were able to supply adequate plant nutrients in this experiment.

Soil Exchangeable Acidity (EA) was low in soils amended with cocoa pod ash and poultry manure. The most important growth-limiting factor in acid soils is believed to be Al toxicity because high levels of soluble and or exchangeable Al combined with low level of Ca impair plant root development and limit water and nutrient uptake by plants (Foy,1992; Rout *et al.*, 2000). The negative effects of these agro wastes on EA will help to release nutrients such as P that have formed complex with Al if the pH is properly monitored.

CONCLUSION

The laboratory incubation study to compare the effect of coca pod ash, poultry manure and NPK 20:10:10 fertilizer on some soil chemical properties was conducted in South Western Nigeria indicated that cocoa pod ash and poultry manure rates significantly increased soil pH, organic OM, N, Ca, Mg, CEC and percent base saturation compared with control, NPK fertilizer rates reduced soil pH. Cocoa pod ash at 10 t ha^{-1} recorded the highest pH and Ca at 30, 60 and 90 days. The NPK fertilizer at 200 kg ha^{-1} had the highest N, P and exchangeable acidity at 30, 60 and 90 days. Cocoa pod ash applied at 10 t ha^{-1} had highest CEC at 60 days of incubation. Cocoa pod ash and poultry manure decreased exchangeable acidity while NPK rates increased it. Cocoa pod ash at 10 t ha^{-1} had the widest Ca: Mg ratio among the treatments and thus may be prone to nutrient antagonism. Cocoa pod ash and poultry manure rates reduced K: Ca ratio compared with control. Among the treatments, OC: N, Ca: Mg and K: Ca ratios fall within the acceptable range for arable crop production in Southwestern Nigeria. Also, cocoa pod ash and poultry manure at 10 t ha^{-1} rates supplied adequate OM, N, P, K, Ca and Mg. Poultry manure and cocoa pod ash could be used to fertilize soil for crop production.

REFERENCES

Adepetu, J.A., A.A. Adebayo, E.A. Aduayi and C.O. Alofe, 1979. A preliminary survey of the fertility status of soils in Indo State under traditional cultivation. Ife J. Agric., 1: 134-149.

Adetunji, M.T., 1991. An evaluation of the soil nutrient status for maize production in South Western Nigeria. J. Agric. Res., 8: 101-113.

Akanni, D.I. and S.O. Ojeniyi, 2007. Effect of different levels of poultry manure on soil physical properties, nutrients status, growth and yield of tomato (*Lycopersicon esculentum*). Res. J. Agronomy, 1: 1-4.

Allison, F.E., 1982. Soil Organic Matter and its Role in Crop Production. Elsveir, Amsterdam, pp: 317.

Anderson, D.L., 1991. Soil and leaf nutrient interactions following application of calcium silicate slag to sugarcane. Nutr. Cycl. Agroecosyst., 30: 9-18.

Anonymous, 1993. Phosphorus interactions with other nutrients. Better Crops, 83: 12-13.

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA., pp: 200-210.

Ayeni, L.S., M.T. Adetunji, S.O. Ojeniyi, S.B. Ewulo and A.J. Adeyemo, 2008. Comparative and cumulative effect of cocoa pod husk ash and poultry manure on soil and nutrient contents and maize yield. Am. Eur. J. Sustainable Agric., 2: 92-97.

Ayeni, L.S., 2009. Integrated application of cocoa pod ash and NPK Fertilizer on soil chemical properties and yield of tomato. Am. Eurasian J. Sustainable Agric., 2: 333-337.

Ayeni, L.S., 2010. Effect of combined cocoa pod ash and NPK fertilizer on soil chemical properties, nutrient uptake and yield of maize. J. Am. Sci., 6: 79-84.

Bernard, P., K. Yerima and E. van Ranst, 2005. Introduction to Soil Science: Soils of the Tropics. Trafford Publishing, Canada.

Bray, R.H. and L.T. Kurtz, 1945. Determination of total organic and available forms of phosphorus in soils. Soil Sci., 59: 39-46.

Egunjobi, O.A., 1975. Possible utilization of discovered cocoa pod husks fertilizer and nematicide. Proceedings of the 5th International Cocoa Research Conference, Sept. 1-9, Ibadan, pp: 541-547.

Foy, C.D., 1992. Soil Chemical Factors Limiting Plant Root Growth. In: Advances in Soil Sciences: Limitations to Plant Root Growth, Hatfield, J.L. and B.A. Stewart (Eds.). Vol. 19, Springer Verlag, New York, pp: 97-149.

Jackson, M.L., 1962. Soil Chemistry Analysis. Prentice Hall Inc., England Wood Cliffs, pp: 56-92.

Mba, C.N., 2006. Influence of organic wastes on plant growth parameters and nutrient uptake by maize (*Zea may* L.). Nig. J. Soil Sci., 16: 145-150.

Mbagwu, J.S.C., 1992. Improving the productivity of degraded Ultisol in Nigeria. II, Changes in physical properties. Bioresour. Technol., 42: 167-175.

Mbah, C.N. and J.S.C. Mbagwu, 2006. Effect of animal wastes on physicochemical properties of a uystric leptosol and maize in Southwestern Nigeria. Nig. J. Soil Sci., 16: 96-103.

McLean, E.O., 1982. Soil pH and Lime Requirement. In: Methods of Soil Analysis Part 2: Chemical and Microbiological Properties, Page, A.L., R.H. Miller and D.R. Keeney (Eds.). ASA and SSSA, New York, USA., pp: 199-224.

Rout, G.R., S.S. Amantaray and P.D. As, 2000. Aluminium toxicity in plants: A review. Plant Biotechnology Division, Regional Plant Resource Centre, Bhubanes war-751015, Orissa, India.

Sanchez, P.A. and J.G. Salians, 1981. Low input technology for managing Oxisols and Ultisols in tropical soils. Am. J. Agron., 34: 280-406.

Sobulo, R.A. and O.A. Osiname, 1987. Soil and fertilizer use in Western Nigeria. Resour. Bull., 11: 20-26.

Sobulo, R.A., 1990. A Literature Review on Soil Fertility Investigation in Nigeria. FMANR, Lagos, pp: 281.

Walkley, J.T. and I.A. Black, 1934. An examination of degtjarett method for determining soil organic matter and proposed modification. Soil Sci., 37: 29-35.

Whalen, J.K., C. Chang, G.W. Clayton and J.D. Carefoot, 2000. Cattle manure amendment can increase pH of acid soils. Soil Sci. Soc. Am. J., 64: 963-966.