Effect of Cocoa Pod Ash and Poultry Manure Combinations on Soil and Plant Nutrient Contents and Performance of Maize – Screenhouse Experiment

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ABSTRACT: A Screenhouse experiment was conducted in 2005 and 2006 on single application of cocoa pod ash (0. 5 and 10t ha $^{-1}$), poultry manure (0, 5 and 10t ha $^{-1}$) and their residual effects on soil chemical properties, nutrient content and yield components of maize in Southwest Nigeria. There were nine treatment combinations replicated three times in a completely randomized design. After treatments application in 2005, the pot soil were left without treatments application in 2006 to determine their residual effects. Compared with control, cocoa pod ash and poultry manure applied significantly increased ($p<0.05$) soil OM, N, P, K, Ca, Mg, Fe and Zn. In 2005, when cocoa pod ash was combined with poultry manure at the rate of 10 t ha-1 each, increases in OM, P, Fe, Zn and Mn were lower than when 5tha $^{-1}$ of cocoa pod ash was combined with 10tha $^{-1}$ poultry manure. 10 t ha-1 of cocoa pod ash reduced soil Fe, Cu, Zn, and Mn compared with 10t ha $^{-1}$ poultry manure. Poultry manure at all rates significantly ($P < 0.05$) increased tissue N, P, K, Ca and Mg compared with control. Cocoa pod ash increased tissue N. K, Ca, Mg Zn, and Mn in 2005 and increased K, Zn, and Fe in 2006. Cocoa pod ash combined with poultry manure increased plant N, P, K, Ca and Mg compared with control. All the treatment combinations significantly ($P < 0.05$) increased plant height, stover, dry root matter and grain yield. The increases in yield in 2005 were 11% (C_0P_5), 61% (C_0P_{10}), 32% (C_5P_0) 64% (C_5P_5), 68% (C_5P_{10}), 9% ($C_{10}P_5$), and 57% ($C_{10}P_{10}$) while the increases in 2006 were 44% (C_0P_5), 98% (C_0P_{10}), 9% (C_5P_0), 34% (C_0P_0), 17% (C_5P_5), 99% (C_5P_{10}) 53% (C_0P_5) and 94% (C_0P_{10}). [Researcher. 2010;2(3):75-80]. (ISSN: 1553-9865).

Key Words: integration, soil nutrients, nutrient uptake, maize yield

INTRODUCTION

In Nigeria, the use of mineral fertilizer in crop production has not been sustainable due to its high cost and scarcity and nutrient imbalance.

Hence, there is renewal interest in locally available agro waste by poor resource farmers to fertilize their farms. The farm wastes and animal excreta are used directly as compost manure and farm yard manure. Due to high quantity needed, adequate quantity of organic wastes may not be obtained; hence the farmers often apply different wastes combined. Since the wastes are of different quantity and nutrient composition, their combined use is expected to have positive cumulative and complementary effects in nutrient supply and improvement in crop yield.

The sole and integrated use of crop wastes such as cocoa pod husk has not received much research attention (Ayeni *et al.*, 2010). About 800,000 tonnes of cocoa pod husks are generated annually in Nigeria and often wasted (Egunjobi, 1976). It is known to harbour fungus causing black pod in cocoa. Its use as organic manure form may directly or indirectly transmit black pod disease to other farms. Hence, cocoa pod are burnt. In the study by Akanni and Ojeniyi, (2007), it was found that cocoa pod husk ash increased growth and nutrient uptake by kola seedlings and soil P, K, Ca and Mg compared with NPK fertilizer.

Animal manures especially that of poultry have received much research attention in crop nutrition and had been found to be effective source of nutrient for crops (Ayeni and Adetunji 2010). Poultry manure has been integrated with mineral fertilizers but there has not been any known trial on integrated plant nutrient involving poultry manure and plant residues. Hence, the objective of this study was to determine the effects of application of cocoa pod husk ash, poultry manure and their combinations on soil chemical properties, nutrient uptake and yield of maize.

MATERIALS AND METHODS

SOURCES OF MATERIALS

Cocoa pod husk were collected from cocoa farmers in Ondo, sun dried and partially burnt into ash inside a bin in December 2004 and kept in a bag. Partial burning of plant residue is a simulation of what the farmers use. Fresh poultry litter from layers was collected from Oka poultry farm in Ondo town, air-dried and ground into fine particles in the month of February 2005.

Maize (SUWAN-1-SR) were bought from Ondo State Agricultural input Supply Company for the conduct of the experiment. The poultry manure and cocoa pod husk ash used were passed through 2mm mesh. Collected soil samples taken from 0 -20 cm depth were bulked, air-dried and sieved through 2mm sieved mesh. Part of the soil samples was used for routine soil analysis and pot experiment.

SOIL ANALYSIS

The pH of the soil was determined in 2:1 CaCI2 / soil suspension using glass electrode pH meter (Crockford and Norwell, 1956). 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 Kjehal method (Jackson, 1962).

Available phosphorus was extracted by 0.03M NH4F + 0.025M HCI (Bray and Kurtz, 1945) and the P in the extract was determined by colorimeter. Exchangeable bases (Na, Ca, K and Mg) were extracted with I.0N ammonium acetate at pH 7.0. Potassium and Na were read using flame photometer while Ca and Mg were determined by AAS (AOAC, 1990). Micro nutrients (Fe, Cu, Zn, and Mn) were extracted with Hec and determined by AAS.

ORGANIC MATERIALS ANALYSIS

The nutrient composition of powdered poultry manure and cocoa pod 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 – 5-5ml of HNO_3 – H_2SO_4 – $HCIO_4$ acids (A.O.A.C, 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 micronutrients by AAS

POT EXPERIMENT
IMMEDIATE EFFECT

Ten kilogram of air-dried soil sample from Adeyemi College of Education research farm site was used per pot. The treatments consisted of 0, 25 and 50g of air dried poultry manure and cocoa pod ash to represent 0, 5 and 10 t ha $^{-1}$ and they were combined in a 2x3 factorial experiment in a completely randomized design. Hand trowel was used to incorporate the organic wastes, copiously watered and four SUWAN – I – SR maize seed were planted/pot two weeks after manure incorporation and thinned down to three maize seedlings per pot. The treatments were replicated three times.

At 45 days after planting, above soil portion of one maize per pot was harvested, washed with clean water, bagged in brown envelops and labeled accordingly. The plant tissues were oven dried at 65^{0}C till constant weight was obtained. The samples were ground with a Willey mill to pass through 0.5mm sieve. The ground samples were digested with nitric – percholoric acid mixtures (A.O.A.C, 1990) as was done in routine soil analysis. Total N was determined by Kjedahl procedure, P was determined by Bray -1- P method. Potassium was determined by AAS. The micronutrients (Fe, Cu, Zn and Mn) were also determined by AAS.

The remaining maize per pot was uprooted and cut from the base to separate the shoot from the root at cob harvest. The root and shoot part of each plant were washed with clean water bagged in brown envelope and labeled accordingly for dry matter determination. The samples were dried in the oven at 65^{o}C until constant weight was recorded. The stover and root yields were weighed. Plant height was also measured. Harvested maize cobs were shelled and sun dried to reduce the moisture content to about 12%. Maize grain /plant were weighed with weighing balance. Soil samples were collected per pot at harvest and processed for routine analysis.

Residual Effect

The pot experiment was repeated in 2006. For the repeated experiment, the soil samples were sieved in order to remove the root fragments and debris of the first crop and carefully placed in pots to minimize soil loss. The soil samples were copiously watered and pulverized before maize seeds were planted in April 2006. No additional treatment was applied in order to determine the residual effects of the earlier applied treatments. Plant nutrients analysis, dry matter determination and soil routine analysis were done as carried out in 2005.

RESULT

The soil used for the conduct of the experiment (Table 1) was low in organic matter (OM), N, K, Cu, Zn and Mn using the established critical level of 3% for OM, 0.15% for N, 8 – 10 mg kg $^{-1}$ for available P, 0.20c mol kg $^{-1}$ for K, and 0.26 c mol kg $^{-1}$ for Mg for these major nutrients; 5, 1, 5, 3 mg kg $^{-1}$ for Fe, Cu, Mn and Zn respectively (Sobulo and Osiname, 1981). Poultry manure was richer than cocoa pod ash in respect to N, P, Mg, Fe and Mn (Table 2).

Table 1. Initial soil analysis

pH	OM	N	P	K	Ca	Mg	Fe^{2+}	Cu^{2+}	Zn^{2+}	Mn^{2+}
	- % -		$mgkg^{-1}$	-------c mol kg^{-1}------			------------- mg kg^{-1}----------			
5.67	1.31	0.06	5.38	0.14	0.23	0.20	2.40	0.48	1.23	4.00

Table 2: Analysis of poultry manure (PM) and cocoa pod ash (CPA)

	OC	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn	Cu
		%	$mgkg^{-1}$	-----c mol kg^{-1}---------			---------mg kg^{-1}---------------------				
PM	1.70	1.19	272	5.91	2.8	8	2.66	0.10	0.40	1.48	6
CPA	6.5	0.59	100	12.52	3.74	2.4	1.22	0.33	0.13	1.22	12

Compared with control, combination of poultry manure and cocoa pod ash at 5 and 10 t ha $^{-1}$ significantly ($P < 0.05$) increased soil organic matter (OM), N, P, K, Ca and Fe in 2005 and 2006 (Table 3 and 4). When cocoa pod ash was combined with poultry manure at 10t ha $^{-1}$ increases in organic matter, P, Fe, Zn and Mn were lower than when 5 t ha $^{-1}$ of cocoa pod ash was combined with 10 t ha $^{-1}$ of poultry manure. Poultry manure gave higher soil OM, N, P, Mg Fe, Zn and Mn than cocoa pod ash but cocoa pod ash at 5 or 10 t ha $^{-1}$ had higher K and Ca in 2005. After one year, poultry manure still gave higher OM, N, P, Mg, Fe Cu and Mn.

Table 3: Effect of combined cocoa pod ash and poultry manure on soil chemical properties in 2005

Treatment	OM	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
	%	%	mg kg^{-1}	----------cmol kg^{-1}-------			------------mg kg^{-1}--------------			
C0P0	2.09f	0.10d	4.92c	0.20c	1.18f	0.87b	0.36c	0.18a	4.33a	30.01a
C0P5	2.91c	0.13c	14.92c	0.25bc	1.70e	0.97b	0.43c	0.13a	3.43a	21.67c
C0P10	3.44a	0.18a	20.00a	0.31a	2.44d	1.17a	0.67a	0.11c	3.93a	31.96a
C5P0	2.90c	0.15b	4.33c	0.22c	2.93b	0.93b	0.33c	0.12bc	3.43a	26.32b
C5P5	2.68c	0.13c	8.39d	0.24c	3.41a	0.63c	0.43c	0.12bc	1.90c	21.67c
C5P10	3.08b	0.15b	12.00c	0.25b	2.34d	0.67c	0.52b	0.12bc	2.40b	21.97c
C10P0	2.85d	0.16b	5.79c	0.36a	3.08c	0.45c	0.47b	0.12bc	2.67b	20.27d
C10P5	2.77c	0.14c	8.66d	0.29b	3.23b	0.86b	0.33c	0.13b	1.67c	18.00e
C10P10	2.92c	0.15b	9.21d	0.26b	3.03c	0.84a	0.40c	0.11c	1.50c	17.80e

Means with the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.
C = cocoa pod ash, P = poultry manure

Table 4: Effect of combined cocoa pod ash and poultry manure on soil chemical properties in 2006

Treatment	OM	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
	%	%	mg/kg	----------cmol kg^{-1}-------			------------mg kg^{-1}-----------------			
C0P0	1.15d	0.05d	4.66e	0.15b	1.52c	0.35c	1.35c	0.57b	1.34e	18.82b
C0P5	1.80e	0.09c	7.62d	0.14c	1.90c	0.53b	1.55b	0.84b	1.36e	12.91e
C0P10	21.62c	0.13a	8.69b	0.14c	2.10a	0.03d	2.03d	1.65a	2.04d	22.68a
C5P0	2.11c	0.10b	7.23d	0.29a	0.03ab	0.33c	1.34c	0.87b	2.51d	16.45c
C5P5	2.04cd	0.11b	8.71b	0.24a	2.17a	0.51b	1.50b	1.20b	3.77a	13.85e
C5P10	2.21c	0.11b	8.31b	0.25a	1.93b	0.98a	1.98a	0.25c	3.01c	14.89d
C10P0	2.15c	0.11b	7.94b	0.25a	2.00a	0.21cd	1.22cd	0.17c	3.03c	13.24e
C10P5	2.35b	0.12ab	9.45a	0.26a	2.10a	0.98a	1.98a	0.17c	3.30b	15.57d
C10P10	2.80a	0.13a	8.07b	0.18b	1.90b	0.98a	1.99a	0.26c	3.37b	11.45f

Means with the same letters are not significantly different according to Duncan Multiple Range Test

Addition of cocoa pod ash and poultry manure at all rates of combinations significantly increased ($P <0.05$) plant height, stover yield and root dry matter (Table 5). Grain yield and dry root matter increased with the level of poultry manure. Cocoa pod ash applied at 5t ha $^{-1}$ had higher yield than cocoa pod ash applied at 10 t ha^{-1}. 5 t ha $^{-1}$ cocoa pod ash combined with 10 t ha $^{-1}$ poultry manure had the highest grain yield in 2005 (Table 5). One year after treatments application, plant height, grain, stover, and root dry mater yield also increased with level of poultry manure (Table 6). Treatment (C_5P_{10}) still had the highest yield followed by C_0P_{10}, C_5P_0, and $C_{10}P_{10}$. The percent means increase for 2005 and 2006 grain yield were 86% (C_5P_{10}), 80% (C_0P_0), 73% (C_0P_{10}), 41% (C_5P_5), 6% ($C_{10}P_0$), 31% ($C_{10}P_0$), 27% (C_0P_5), 21% (C_5P_0).

Table 5: Effect of combined cocoa pod ash and poultry manure on agronomic parameters of maize 2005

Trt	plant height (cm)	grain yield (g)	stover yield (g)	dry root matter (g)	% increases in grain yield
C0P0	123.25	33.02	18.33	10.83	0
C0P5	124.67	36.56	22.58	14.11	11
C0P10	148.78	50.56	32.61	12.89	53
C5P0	122.11	38.78	25.15	15.89	17
C5P5	147.22	54.09	38.19	23.33	64
C5P10	135.56	53.22	39.11	19.00	61
C10P0	144.56	43.71	27.97	15.22	32
C10P5	142.33	36.00	21.44	14.11	9
C10P0	150.00	50.16	33.99	16.59	52

Means with the same letter are not significantly different according to Duncan Multiple Range Test at 5% level.

Table 6: Effect of combined cocoa pod ash and poultry manure on agronomic parameters of maize in 2006

Trt	plant height (cm)	grain yield (g)	stover yield (g)	dry root matter (g)	% increase in grain yield
C0P0	58.83a	8.06f	10.63h	3.28d	0
C0P5	55.11a	21.58c	32.09c	12.34a	168
C0P10	56.22a	28.55a	37.65a	12.43a	254
C5P0	50.89a	8.78g	11.63g	3.50d	9
C5P5	57.89a	9.86f	22.96d	7.74b	17
C5P10	62.67a	26.16b	33.75b	12.10a	225
C10P0	58.11a	5.82g	12.06f	4.51c	34
C10P5	61.11a	12.32e	18.03e	5.98c	53
C10P0	68.56a	15.65d	22.29d	7.52b	94

Means with the same letter are not significantly different according to Duncan Multiple Range Test at 5% level.

Addition of cocoa pod ash to poultry manure at 5 and 10 t ha $^{-1}$ increased tissue N, P, K, Ca and Mg. treatment C5P10, C10P5 and C10P10 increased Fe, Cu and Zn while C5P5 reduced Cu concentration in maize tissue (Table 7). In 2006, addition of 5 t ha^{-1} cocoa pod ash to either poultry manure at 5 or 10 t ha^{-1} poultry manure increased tissue N, P, Ca, Mg, Zn, Cu, Fe and Mn (Tables 8) poultry manure rates increased tissue N, P, K, Ca, Mg, Zn, and Fe.

Table 7: Effect of combined cocoa pod ash and poultry manure on nutrient concentration in maize tissue in 2005

Treatment	N	P	K	Ca	Mg	Zn	Cu	Fe	Mn
	------------------%				---	--------------------mg kg^{-1}------------			
C0P0	2.14c	0.37	2.12f	0.22c	0.14c	18.14g	3.76f	25.43a	23.06c
C0P5	2.47b	0.44	3.71c	0.33b	0.18a	27.54f	5.65b	23.83bc	33.20a
C0P10	3.29a	0.45	4.03b	0.36b	0.18a	39.77b	5.07c	24.33b	30.15b
C5P0	2.68b	0.35	3.54	0.24c	0.16b	31.80e	3.42g	23.27c	19.95d

C5P5	3.01a	0.38	4.04b	0.54a	0.17ab	34.07d	3.45g	21.33d	24.97c
C5P10	3.29a	0.49	3.65d	0.53a	0.16b	28.22d	7.18a	21.63d	26.34c
C10P0	2.37ab	0.37	4.70a	0.24c	0.17ab	48.77a	2.90h	21.13d	25.65c
C10P5	3.04a	0.37	3.33e	0.42b	0.16b	37.40c	4.10d	16.47e	24.98c
C10P10	3.39a	0.40	3.66d	0.29c	0.16b	48.72a	4.03e	16.67e	26.31c

Table 8: Effect of combined cocoa pos ash and poultry manure on nutrient concentration in maize tissue in 2006

Treatment	N	P	K	Ca	Mg	Zn	Cu	Fe	Mn
	%					mg kg^{-1}			
C0P0	0.37a	0.12b	1.32	0.16c	0.10a	22.89e	3.21b	13.39d	26.73a
C0P5	0.41a	0.16a	1.41ab	0.21a	0.13a	26.41d	4.06b	20.13a	15.84b
C0P10	0.42a	0.20a	1.43a	0.21a	0.17a	38.28b	6.12a	20.00a	10.37c
C5P0	0.49a	0.10b	1.44a	0.16c	0.08a	31.71c	2.96b	17.94b	14.74b
C5P5	0.50a	0.11b	1.45a	0.19a	0.09a	33.76c	3.25b	21.38a	11.01bc
C5P10	0.54a	0.19a	1.44a	0.22a	0.16a	32.91c	6.33a	20.08a	9.87e
C10P0	0.49a	0.11b	1.43a	0.16c	0.09a	30.61cd	2.89b	15.25c	9.81c
C10P5	0.48a	0.12b	1.43a	0.17bc	0.10a	32.10c	3.21b	17.22b	12.42b
C10P10	0.62a	0.14b	1.48a	0.19b	0.11a	43.74a	3.70b	20.15a	8.80e

Means with the same letter are not significantly different according to Duncan Multiple Range Test (DMRT) at 5% level.

DISCUSSION

Analysis of poultry manure and cocoa pod ash showed that they were composed of N, P, Mg, Fe, Cu, Zn and Mn. The two organic materials combined had cumulative and complementary effect on nutrient availability to maize. Cocoa pod ash and poultry manure increased significantly ($P < 0.05$) soil organic matter, soil macro and micro nutrient contents as well as maize yield on immediate and residual basis.

The increases in soil and plant nutrients content adduced to cocoa pod ash and poultry manure is consistent with the finding that the materials are composed of macro and micronutrients, studies by Ayeni, (2008), and Odedina *et al* (2003) also showed that cocoa pod ash increased soil organic matter, N, P, K, Ca, and Mg.

The finding that cocoa pod ash increased nutrients concentration in maize tissue can be related to earlier observations of Moyinjesu, (2007) that cocoa pod ash increased N, P, K, Ca and Mg of okra tissue. Ajayi *et al*, (2007) also found that cocoa pod ash increased growth of kola (*cola nitida*) seedlings.

The finding that the poultry manure increased grain yield than cocoa pod ash can be related to lower C/N ratio which ensured quicker release of N and P which are respectively the major nutrient limiting maize yield in Southwestern Nigeria where this work was carried out. The finding that combined application of cocoa pod ash and poultry manure gave highest yield attests to the complementary effect of the two organic materials in the release of nutrients for maize uptake as indicated in the experiment conducted by Ayeni *et al* (2008) and Ayeni. (2010) on the comparative and cumulative effect of cocoa pod ash and poultry manure on soil, maize nutrient contents and yield.

Among the treatment combinations, it was noted that 5 t ha $^{-1}$ of cocoa pod ash combined with 10 t ha $^{-1}$ poultry manure had the highest yields. This could be as a result of the balanced nutrient it enjoyed as it was not deficient in any nutrient. Even Cu which was deficient in maize plants in other treatments was not deficient in $C_5P_{10.}$ Cu value fell between the critical range C_5P_{10} of 6 – 40 mg kg $^{-1}$ recommended by Brady and Weil, (1999). The finding that maize planted in 2005 had higher yields than maize planted in 2006 without additional treatments suggested that the source of nutrients for maize in 2005 was directly from the treatments applied. The lower performance of maize in 2006 (on residual basis) compared with maize planted in 2005 showed that the combined organic wastes had little residual effect because the treatments applied in 2005 (first crop) had utilized the bulk of the nutrient supplied by cocoa pod ash, poultry manure and their combinations. This shows that the treatments could not supply adequate nutrients for maize up to two years since all the crops showed stunted growth. There is need for additional fertilizer in the second year.

CONCLUSION

Combined cocoa pod ash and poultry manure served as source of major and micro nutrients for soil fertility maintenance and performance of maize crop.

Cocoa pod ash combined at lower level (5 t ha $^{-1}$) with poultry manure at 5 or 10 t ha $^{-1}$ was more effective in the release of N and P as well as yield than when highest level of cocoa pod ash combined with lower level of poultry manure. Combined organic wastes can be used as nutrient source for maize in the absence of mineral fertilizer.

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