Integrated Application of Cocoa Pod Ash and NPK Fertilizer: Effect on soil and Plant Nutrient Status and Maize Performance – Field Experiment

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Abstract: Field experiment was conducted to study the effect of application of cocoa pod ash and its integrated application with reduced levels of NPK 20:10:10 fertilizer (NPKF) on soil and plant nutrient, growth and grain yield of maize at Ondo in the rainforest zone of south west Nigeria. There were 10 treatments involving a control, ash applied at 5 and 10 t ha^{-1}, 100, 200, 400 kg ha^{-1} NPK fertilizer and combined use of ash with 100 or 200 kg ha^{-1} fertilizer. The treatments were replicated three times on field and the residual effect (one year later) on soil and plant macro and micro nutrient concentration, growth and grain yield of maize was studied. The soil in the experimental site was deficient in organic matter (OM), N, K and Mg. Application of cocoa pod ash, NPK fertilizer and their combinations significantly ($p<0.05$) increased soil organic matter, P, K, Ca, Mg, plant N, P and K, height, stover, root and grain yield on immediate and residual basis. NPKF also significantly (p<005) increased soil and plant Fe, Cu, Zn and Mn. Ash also increased plant Ca and Zn. Combined application of ash with 100 or 200 kg ha^{-1} NPKF, and NPKF (400 kg ha^{-1}) gave similar and highest cumulative grain yield varying between 5.4 to 5.9 t ha^{-1}. The control, cocoa pod ash at 10 t ha^{-1} and NPKF at100 kg ha^{-1} respectively gave least cumulative grain yield of between 3.3 and 4.2t ha^{-1} for two years of study. The ash alone or combined with reduced NPKF gave highest residual effect on yield with increases of between 52 to 76% relative to control. [Journal of American Science 2010; 6(6):96-102]. (ISSN: 1545-1003).

Key words: integration, immediate and residual effect, yield

1 Introduction

In tropical countries, high cost and scarcity of fertilizer, nutrient imbalance and soil acidity are problems associated with use of inorganic fertilizers which led to recent interest in use of agricultural wastes as nutrient source in crop production. Also research has shifted to integrated application of organic and inorganic fertilizers. Some studies confirmed that combined application of these fertilizers gave superior effect in terms of balanced nutrient supply; improve soil fertility and maize yield compared with use of either of the fertilizers (Ajayi *et al*, 2007b). Other advantages of combined application of organic and inorganic fertilizers are that it would reduce the quantity of fertilizer required, and aid release of nutrient from organic sources.

Cocoa pod husk and its ash have not been adequately investigated in plant nutrition. Moyin Jesu (2007a, Ayeni, 2008a) after extensive literature search noted scarcity of report on use of cocoa husk in plant nutrition. Egunjobi (1976) found that ground cocoa husk applied to soil increased maize yield by 124%, also increased uptake of P, K and Mg. The effect of cocoa pod husk ash as nutrient source for kola seedlings was investigated (Ajayi *et al*, 2007a and 2007b). The cocoa pod ash increased growth and nutrient uptake by kola seedlings, and soil P, K, Ca and Mg were increased. Compared with NPK fertilizer, cocoa pod ash at 2, 4, 6, 8 and 10 t ha^{-1} increased root N, P, K, Ca and Mg with increased level of ash. The effect of animal manure amended cocoa pod husk on tomato was also studied (Ojeniyi, *et al*., 2007, Ayeni, 2008b). Amended husk significantly increased growth and yield of tomato.

About 800, 000 tonnes of cocoa pod husk are generated annually in Nigeria and often wasted. It is advised that the husk be burnt into ash as method of farm sanitation and for the control of black pod disease. The husk left on the farm harbours the fungus causing the black pod disease. This work studied the immediate and residual effect of integrated application of cocoa pod ash and NPK fertilizer in maize production with reference to effect on soil and plant nutrient uptake, growth and yield of maize.

2 Materials and methods

Field experiment was carried out on sandy clay Alfisol at Ondo (07^0 05^1 N, 04 55^1 N) in the rain forest zone of southwest Nigeria. The site was cultivated to maize, yam and cassava for more than ten years. The land was manually cleared and ridges with a spacing of 30cm x 75cm.

There were ten manurial treatments involving NPK 20:10:10 fertilizer (NPKF) at 100 (C0F100), 200 (C0F200), 400 (C0F400), kg ha^{-1}, NPK 20:10:10 fertilizer at 100 and 200 kg ha^{-1} were combined with 5 t

ha^{-1} of cocoa pod ash (C5F0, C5F100, CF200) and 10 t ha^{-1} (C10F0, C10F100, C10F200). There was a control without any manure or fertilizer (C0F0). The treatments were replicated three times on maize using a randomized complete block design. Each plot was 5m x 5m. Cocoa pod ash was incorporated using hoe at 2 weeks before planting in March 2005, and NPKF was applied in ring form immediately after hoeing at two weeks after planting. SUWAN maize type was planted.

Soil Analysis

Before commencement of experiment, surface (0 - 20 cm depth), the soil samples were collected inn zig - zag method over the site of experiment using auger, bulked, air – dried and 2 mm sieved for analysis. Samples collected over each treatment were also processed similarly. Chemical was done as described by Cater (1993). Organic matter (OM) was determined using wet dichromate method, total N by Kjedahl method. Available P as extracted using Bray -1- method, and determined by molybdenum blue colorimetry. Exchangeable K, Ca and Mg were extracted using ammonium acetate; K was read on flame photometer, Ca and Mg on atomic absorption spectrophotometer. The Mn, Fe, Zn and Cu were extracted using 0.1N HCl and read using atomic absorption spectrophotometer.

Leaf Analysis

Leaf samples collected from five randomly selected plants at 45 days after planting were dried at 65^o C to constant weight. The dried leaves were then ground to pass through 0.5mm sieve and chemically analyzed as described by Tel and Hagarty (1984). 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 – H2SO$_4$ – $HClO_4$ acids (AOAC, 1994). The digest was used for nutrient determination as mentioned for soil analysis. Cocoa pod ash was analyzed as described for leaf.

Yield components

At harvest (90days after planting), five plants were randomly selected and uprooted to determine plant height, roots separated from shoot to determine shoot and dry root matter. The parts were oven dried at 75 ^{o}C until constant weight. Forty maize plants were thereafter selected from the middle row and harvested. Cobs were air – dried, shelled and grain yield determined at 12% moisture content. Grain yield per hectare was calculated.

Residual Effects

In 2006, the experiment was repeated and the same treatments plots were maintained for maize planting without new treatments. Crop and soil analysis data were generated as for 2005 experiment in order to study effect of treatments at one year after the first experiment.

Statistical Analysis

The Duncan multiple range test was used to compare the mean data at 5% level.

3 RESULTS

The sandy clay soil at site the of experiment had 1.31% OM, 0.06% total N, 4.9 mg kg^{-1} available P, 0.16 c mol kg^{-1} exchangeable K, 2.32 c mol kg^{-1} Ca, 0.20c mol kg^{-1} Mg, pH (H_2O) 5.8, Fe 2.44 mg kg^{-1}, Cu 0.41 mg kg^{-1}, Zn 3.3 mg kg^{-1} and Mn 4.2 mg kg^{-1}. Using established critical levels for these nutrients (Kayode and Agboola, 1994, Agboola, 1994), the soil was deficient in OM, N, P, Mg, Cu, Fe and Mn with respect to maize production. This finding is in contrast with the widely held view that soils in the rainforest area were not deficient in these micronutrients. The deficiency in nutrient status is attributable to long term cropping of the land to staple crops such as yam, cassava and maize. Therefore, the test maize crop and the soil are expected to benefit significantly from cocoa pod ash and NPKF.

Cocoa pod ash had 14.52% OC, 0.68%N, 0.50%P, 11.9%K, 2.9%Ca and 0.40% Mg with C: N ratio of 12.3. This value of C: N is conducive for rapid degradation and dissolution of ash. Hence, it is expected that the nutrients in the ash would be released for uptake of maize. The ash is expected to release other nutrients such as micronutrients to the benefit of the soil and crop. Analytical data of cocoa pod husk given by Sobamiwa and Longe (1994) and cocoa pod ash (Ayeni *et al.*, 2008a and 2008b) showed that it contained, K, P, Mg and lower values of Zn, Fe, Cu and Mg.

Relative to control, cocoa pod ash, NPK fertilizer applied at 200 and 400 kg ha^{-1} and combination of ash with 100 and 200 kg ha^{-1} significantly ($p<0.05$) increased soil OM, K and Ca (Table 1 and 2).

Combined cocoa pod ash and NPKF significantly ($p<0.05$) increased soil N and Fe (Table 1& 2). One year after treatments application, all the treatments increased soil P and K relative to control. NPKF increased availability of Zn and Mn, which tended to increase with level of fertilizer. The fertilizer also significantly ($p<0.05$) increased soil Cu and Fe in 2005 and the elements increased with level of NPKF. Thus, NPKF tended to enhance presence of the micronutrients.

Addition of NPKF to cocoa pod ash significantly increased ($p<0.05$) soil OM, N, P, K, Mg, Zn and Fe in the fist year. The same observation applied to soil K and P one year after treatments application especially with cocoa pod ash at 5t ha^{-1}.

Table 1: Effect of combined cocoa pod ash and NPK fertilizer on soil chemical properties in field experiment in 2005

Treatment	OM	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
	%	%	mg kg^{-1}	------------c mol kg^{-1}-----------			-----------mg kg^{-1} ----------------------			
C0F0	3.45bc	0.19b	8.21c	0.23c	3.82c	1.27ab	1.53b	1.12a	3.55d	21.23bc
C0F100	3.30c	0.18b	8.92b	0.28bc	3.82c	1.25b	1.33c	1.06b	3.90c	22.80b
C0F200	3.56b	0.19b	8.99b	0.28bc	4.00c	1.73a	1.72a	1.04b	4.31b	24.51b
C0F400	3.70b	0.19b	14.53a	0.31a	2.13d	0.93c	1.17d	0.62d	5.12a	36.72a
C5F0	3.38c	0.18b	9.10b	0.31a	4.26bc	1.13b	1.89a	0.62d	1.41f	18.78c
C5F100	3.62b	0.19b	10.52a	0.37a	4.08c	1.50a	1.18d	0.60d	2.70e	19.24c
C5F200	2.60b	0.21a	9.98ab	0.35a	3.68c	1.47a	1.17d	0.61d	2.85e	20.02c
C10F0	3.24c	0.17b	8.45bc	0.19c	5.23a	0.60d	1.21d	0.70c	0.75h	14.97d
C10F100	3.40c	0.18b	9.07b	0.36a	4.66b	1.03c	1.14d	0.25e	0.95h	15.89d
C10F200	4.08a	0.20a	10.05a	0.38a	4.50b	1.03c	1.16d	0.23e	1.64g	16.81d

Table 2: Residual effect of combined cocoa pod ash and NPK fertilizer on soil chemical properties in year 2005

Treatment	OM	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
	%	%	mg kg^{-1}	------------c mol kg^{-1}-----------			-----------mg kg^{-1}			
C0F0	2.24c	0.11b	7.91b	0.17c	1.95d	1.00b	1.04e	0.45c	6.16a	30.11a
C0F100	2.44c	0.11b	7.91b	0.17c	1.78d	1.03b	1.30c	0.84b	3.99c	20.32c
C0F200	2.32c	0.11b	8.00b	0.17c	2.01d	1.03b	1.19d	0.86b	3.25dc	18.88c
C0F400	2.94a	0.14a	9.20a	0.27b	1.47e	1.03b	1.61b	1.02a	4.00c	20.44c
C5F0	2.53c	0.12ab	8.60b	0.20c	2.64c	1.13a	1.64b	1.17a	5.04b	24.54b
C5F100	2.31c	0.11b	9.76a	0.21a	2.81b	1.10a	1.74b	1.14a	5.05b	22.88b
C5F200	2.60b	0.13a	7.68a	0.28a	2.45c	1.06b	1.64b	0.46c	3.09d	19.10c
C10F0	2.78b	0.14a	7.18a	0.26ab	3.03a	1.07b	1.96a	0.19e	2.94d	18.58c
C10F100	3.04a	0.15a	8.32b	0.34a	2.70b	1.07b	1.92a	0.16e	1.63e	16.05c
C10F200	2.76b	0.14a	8.05b	0.31a	3.05a	1.12a	1.91a	0.31d	3.09d	25.22b

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

Cocoa pod ash, NPKF and their combinations significantly increased ($p<0.5$) plant N, P and K (tables 3 & 4). Ash at 5 t ha^{-1} alone combined with fertilizer significantly increased plant Ca and Zn. In the second year, cocoa pod ash applied alone or combined with NPK fertilizer increased N uptake. Addition of NPKF to ash increased plant P, K, Zn, Fe and Mn (at 10 t ha^{-1} only).

Table 3: Effect of combined cocoa pod ash and NPK fertilizer on maize nutrient concentration in 2005

Treatment	N	P	K	Ca	Mg	Zn	Cu	Fe	Mn
	---------------------- % ----------------------					-------------------- mg kg^{-1}--------			
C0F0	2.15c	0.36b	2.64h	0.26c	0.16ab	28.68f	5.33e	23.03c	26.80c
C0F100	2.61b	0.40ab	3.29g	0.27c	0.15b	30.15d	2.75i	22.57c	28.16b
C0F200	2.71b	0.46a	3.56e	0.35b	0.17a	25.43g	6.32a	25.20b	31.28a
C0F400	3.44a	0.47a	3.45e	0.30b	0.17a	21.72h	4.00f	27.80a	23.53d
C5F0	3.03a	0.38b	3.79d	0.49a	0.17a	30.70e	5.04b	19.97cd	26.40c
C5F100	2.94a	0.42a	4.27a	0.29c	0.16ab	33.30d	4.52d	22.57c	23.63d
C5F200	3.00a	0.42a	3.17g	0.52a	0.17a	30.20e	4.49e	23.10c	21.89e
C10F0	3.05a	0.33b	3.52e	0.40a	0.17a	39.67c	3.72g	15.40e	22.27de
C10F100	3.11a	0.38b	4.04c	0.26c	0.15b	49.82b	3.62h	18.53d	27.05c
C10F200	3.03a	0.43a	4.14b	0.29c	0.16ab	45.41a	3.68h	19.93d	27.65bc

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

Table 4: Effect of combined cocoa pod ash and NPK fertilizer on maize nutrient concentration after one year of application

Treatment	N	P	K	Ca	Mg	Zn	Cu	Fe	Mn
	------------%----------------------------------					------------mg kg^{-1}-----------------			
C0F0	1.43b	0.26a	1.42b	0.20a	0.14a	35.35b	4.68a	18.22a	16.92bc
C0F100	1.38d	0.25a	1.39c	0.18a	0.13a	23.54d	4.12a	17.07b	17.43a
C0F200	1.40b	0.25a	1.42b	0.19a	0.12a	29.75c	4.47a	16.68b	20.00a
C0F400	1.34b	0.25a	1.36a	0.17a	0.12a	19.69e	3.56a	18.00a	22.50a
C5F0	1.39c	0.24a	1.44b	0.19a	0.12a	32.42b	4.39a	20.04a	15.34c
C5F100	1.49a	0.23a	1.44b	0.19a	0.11a	31.75b	4.20a	19.70a	9.54d
C5F200	1.55a	0.23a	1.45b	0.19a	0.10a	34.21b	3.95a	19.65a	10.74d
C10F0	1.40b	0.23a	1.40b	0.17a	0.10a	30.95bc	3.18ab	17.62b	9.97d
C10F100	1.67a	0.21a	1.50a	0.18a	0.10a	43.37a	2.94b	18.65a	10.83d
C10F200	1.51a	0.22a	1.43b	0.17a	0.10a	32.13b	3.69a	16.36c	10.23d

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

Relative to control, cocoa pod ash, NPKF and combination of reduced level of NPKF with the ash increased significantly ($p<0.05$) plant height, stover yield, root yield and maize grain yield in first year and second year (Tables 5 and 6). However, the ash at 10 t ha^{-1} did not increase yield significantly. Also, the NPKF at 100 and 400 kg ha^{-1} did not increase yield significantly one year after treatments application.

On immediate basis, NPKF at 400 kg ha^{-1}, ash (5t ha^{-1}) + NPKF at 100kg ha^{-1}, ash (10t ha^{-1}) + NPKF 200kg ha^{-1} and NPKF 200 kg ha^{-1} respectively gave highest grain yield increases being 116, 91, 80 and 65% respectively over the control. One year after treatments application, ash (10t ha^{-1}) + NPKF 200kg ha^{-1}, ash 10t ha^{-1} + NPKF 100 kg ha^{-1}, ash 10 t ha^{-1} and ash 5 t ha^{-1} + NPKF 100 kg ha^{-1} gave highest increases respectively being 76, 63, 58 and 52% respectively. The ash 5t ha^{-1} + NPKF 100kg ha^{-1}, NPKF 400 kg ha^{-1}, ash 10 t ha^{-1} + NPKF 200 kg ha^{-1}

and ash 5 t ha^{-1} + NPKF 200 kg ha^{-1} a respectively gave highest and similar cumulative grain yield of 5.85, 5.60, 5.54 and 5.40 t ha^{-1} respectively. The control, ash at 10 t ha^{-1}, NPKF at 100 kg ha^{-1} and ash at 5 t ha^{-1} respectively gave least cumulative yield of 3.3, 4.2, 4.4 and 4.6 t ha^{-1} respectively. By combining cocoa pod ash at 5 t ha^{-1} with NPKF at 100 kg ha^{-1}, the requirement for the fertilizer in maize production is reduced by 75%.

Table 5: Effect of cocoa pod and NPK20:10:10 combinations on agronomic parameters of maize in 2005

Treatments	Height cm	Grain yield t ha^{-1}	Stover yield t ha^{-1}	Root Yield t ha^{-1}	increase in grain yield%
C0F0	162.12b	1.98d	3.83c	1.23e	0
C0F100	204.18a	2.95bc	4.61b	1.23e	25
C0F200	221.40a	3.27b	5.12a	1.81b	65
C0F400	204.67a	4.27a	5.42a	2.03a	116
C5F0	184.22c	2.84c	4.39b	1.33e	43
C5F100	201.68a	3.79b	4.68b	1.46d	91
C5F200	200.11a	3.67b	4.65b	1.69c	49
C10F0	178.70b	2.04d	3.07e	0.87g	39
C10F100	198.67b	2.76c	3.60d	0.90f	59
C10F200	207.00a	3.15b	4.15b	1.31e	80

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

Table 6: Residual effect of cocoa pod ash and NPK20:10:10 on agronomic parameters of maize after one year of application

Treatments	Height cm	Grain yield t ha^{-1}	Stover yield t ha^{-1}	Root Yield t ha^{-1}	increase in grain yield%
C0F0	143.44b	1.36c	2.30cd	0.20c	0
C0F100	154.17a	1.40c	2.08e	0.38c	3
C0F200	165.44a	1.63b	2.26d	0.34c	20
C0F400	168.33a	1.38c	2.08e	0.34c	2
C5F0	163.11a	1.73b	2.37c	0.24c	27
C5F100	178.22a	2.06ab	2.87b	0.30c	52
C5F200	168.56a	1.68b	2.49c	0.41b	19
C10F0	161.56a	2.15a	2.97a	0.44b	58
C10F100	173.22a	2.22a	2.91b	0.47b	63
C10F200	168.67a	2.39a	2.77b	0.79a	76

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

Although, the cocoa pod ash increased stover and grain yield significantly, NPKF at 400 kg ha^{-1} gave higher yield in first year. But one year after treatments application, cocoa pod ash gave higher stover and grain yield than NPKF the accumulative grain yield were 4.2 t ha^{-1} for 10t ha^{-1} ash, 4.6t /ha for 5t ha^{-1} ash, 4.4 t ha^{-1} for PKF 100 kg ha^{-1}, 5.0 t ha^{-1} for NPKF 200 kg ha^{-1} and 5.6t ha^{-1} for NPKF 400kg ha^{-1}. Therefore NPKF at 200 and 400 kg ha^{-1} gave higher yield than cocoa pod ash but the yield are similar with 5 t ha^{-1} ash especially when combined wit 100kg ha^{-1} NPKF

4 Discussion

Cocoa pod ash, NPK fertilizer and their combinations (with reduced level of fertilizer) increased soil OM, P, K and Ca significantly and the combination increased N. One year later, all the treatments increased soil P and K this indicates that the ash had effect on availability of P, and Ca. It was also found that addition of NPK fertilizer to the ash increased nutrient released from ash as indicated by increase in soil OM, N, P, K, Mg, Zn and Fe especially if the ash supplied at 5 t ha^{-1}. The NPK fertilizer increased the Cu, Fe, Mn and Zn status of soil whereas cocoa pod ash tended to reduce it. This is attributable to the fact that NPK fertilizer is known to increase soil acidity (Moyin Jesu, 2007a), a situation that favours availability of these micronutrients (Brady and Weil, 1999). Cocoa pod ash has been found to reduce soil acidity significantly and increase soil OM, P, K, Ca and Mg (Ayeni and Adeleye 2009,Ajayi *et al.*, 2007a, Ayeni *et al*., 2008a). Moyin Jesu (2007a) also found that cocoa husk increased soil OM, N, P, K, Ca, Mg and pH. Similar observation was made by Moyin Jesu (2007b) and Ojeniyi *et al*., (2007) therefore the present work and other recent ones affirmed hat cocoa pod and it ash released N, PK Ca and Mg into soil, when used alone or combined with NPK fertilizer.

Application of cocoa pod ash alone, NPK fertilizer and their combinations increased plant N, P and K. ash alone increased plant Ca and had residual effect on N. Hence, the ash increased nutrient uptake. Previous studies had found that cocoa husk increased uptake of N, P, K, Ca and Mg by okra (Moyin Jesu, 2007a) and Arabica coffee seedling (Moyin Jesu, 2007b) . Addition of NPKF to cocoa pod ash increased plan P, K, Zn, Fe and Mn. This affirms the observation that NPK fertilizer in addition to the supply of N, P and K enhanced the availability of micronutrients in the soil. The combination of the two materials would have ensured a more balanced nutrition. While the ash was particularly effective in increasing K and Ca, The NPK fertilizer was particularly effective in increasing the availability of N, P and the micronutrients. The combined application therefore is expected to influence maize yield better than use of the fertilizer or cocoa pod ash alone.

Hence, it was found that, although the ash and fertilizer significantly increased maize growth parameters and yield on immediate and one year later, addition of NPK fertilizer to cocoa pod ash (especially at 5 t ha^{-1})gave higher cumulative yield covering the immediate and residual cases. Addition of the fertilizer to the ash which increased plant P, K, Zn, Fe and Mn, and soil O, N, P, K, Mg, Zn and Fe and increased grain yield, stover and root yield. The combined use of the materials gave cumulative yield higher than NPK fertilizer. However, the NPK fertilizer gave higher yield than the ash or combined applications in the first year which is attributable to quicker release of N, P and K than from the organic ash source. The ash unlike the mineral fertilizer had residual effect n plant N and increased plant Ca. It also ensured availability of K, Ca and Mg on immediate and one year later. The increase performance of maize due to cocoa pod ash is consistent with earlier finings (Ajayi *et al*., 2007a, 20007b) that cocoa pod ash increased growth of kola seedling significantly. Moyin Jesu, (2007a, 2007b) also found that ground cocoa husk increased growth and yield of okra and growth of coffee seedling respectively. The more balanced nutrition due to combination of NPK fertilizer and cocoa pod ash ensured high cumulative yield than use of ash or NPK fertilizer alone. In fact the ash alone gave least yield although which were higher than the control. The combination of cocoa pod ash with NPK fertilizer reduced need for the fertilizer to 100 or 200 kg ha^{-1}. If the ash was applied at 5t ha^{-1}, the requirement for NPK fertilizer becomes 100 kg ha^{-1} instead of the recommended 400 kg ha^{-1}. With the use of ash at 10t ha^{-1}, it was found that Zn and Cu were below the critical level of 3 ad 1g kg^{-1} respectively. Hence, the 5t ha^{-1} ash recommended to be used with 100kg ha^{-1} NPK fertilizer. Also the plant N, P, K and Mg were below the critical levels of 2.8%, 0.25%%, 1.73% and 0.2 – 0.4% respectively (Agboola, 1994) for the second crop of maize. Hence the yield of untreated second plant fell relatively to the first crop. Therefore it is necessary that the second crop receive NPKF since fertilizer has less residual effect compared with cocoa pod ash in this experiment. The residual effect recorded for NPKF relative to control was between 2 to 20%, whereas it was between19 to 76% for treatments involving ash alone or combined with NPK fertilizer

CONCLUSION

Cocoa pod ash at 5t ha^{-1} increased availability in soil and uptake of N, P, K, Ca and Mg by maize plant. This led to significant increases in growth and grain yield of maize. The combined application of the ash with reduced level (100 or 200 kg ha^{-1}) of NPK fertilizer was more effective in increasing cumulative yield of maize than NPK fertilizer or ash alone. However, NPK fertilizer at 400kg ha^{-1} gave higher yield than the ash at 5 or 10t ha^{-1} or its combined use with fertilizer on immediate basis. The ash had more residual effect on yield than NPK fertilizer.

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