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ORIGINAL ARTICLE

Integrated Application of Cocoa Pod Ash and NPK Fertilizer on Soil Chemical Properties and Yield of Tomato

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ABSTRACT

Field experiments were conducted at two locations (Adeyemi College of Education Research Farm and Fagun) in southwest Nigeria to study effect of application of cocoa pod ash and its integrated application with reduced level of NPK 20:10:10 fertilizer on soil and plant nutrient content, growth and fruit yield of tomato. Three levels of NPK fertilizer at 0 and 100 kg ha^{-1} were combined with three levels of cocoa pod ash at 0, 5 and 10 t ha^{-1}. 300 kg ha^{-1} NPK fertilizer served as reference control. The treatments were replicated three times and repeated in the second year on the same locations without new treatments application in order to determine the residual effects of the treatments previously applied after one year. The soil at Adeyemi was deficient in soil OM, N, P, K, Ca and Mg while Fagun was fairly adequate in crop production. Cocoa pod ash combined with NPK fertilizer significantly ($p<0.05$) increased soil OM, P, K, Ca, and Mg than single application of cocoa pod ash or NPK 20:10:10. Fertilizer combinations also increased N, P and K in the two locations than single application of cocoa pod ash and NPK fertilizer significantly. 10 t ha^{-1} of cocoa pod ash combined with 100 kg ha^{-1} of NPK fertilizer gave the highest fruit yield at the two locations (146% for Fagun and 175% for Adeyemi).

Key words: cocoa pod ash, fertilizer, integration, nutrient, tomato

Introduction

In tropical countries, high cost, scarcity, nutrient imbalance and soil acidity are problems associated with the use of mineral fertilizer while bulkiness, low nutrient quality and late mineralization were the bottleneck in the sole use of organic manures for vegetable production. Hence there is need for integrated application of mineral fertilizer and organic manure that can add lime and nutrients to soils for optimum soil fertility.

Cocoa pod is known to be cheap in southwest Nigeria (Egunjobi, 1975). It is advised the husk be burnt to serve as farm sanitation and reduce the incidence of P*hytophtoral palmivora* which is the causal of black pod disease of cocoa. Burning of cocoa husk also reduces its C/N ratio and therefore enhances its early mineralization Cocoa pod ash is rich in K and Ca (Ayeni, 2008a).

Integrated application of cocoa pod ash with reduced level of NPK fertilizer in tomato production is expected to solve the problems associated with the sole use of mineral fertilizer and organic manures by tomato farmers. Combined cocoa pod ash and NPK fertilizer is not known to have been studied for tomato production in southwest Nigeria.

Materials and methods

Experiments were conducted at two different locations in Ondo area (Adeyemi College of Education Students Research Farm and Fagun) Ondo is located in latitude 07^0 05^1N, on longitude 040^0 55^1E and at an elevation of 381.3M above sea level. The mean annual rainfall of 1575.6mm is distributed over nine to ten

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months in a bimodal rainfall pattern. Early rain occurs between March to July and late rain occurs between August to October with five months of dry season and a short dry spell in August (August break) The two soils were skeletal, clayey, kaolinitic oxic tropuldalf (Adepetu *et al*., 1979). Fagun is more or less fadama (hydromophic soil). The experiments were carried out concurrently in the two locations in September 2006 and repeated in March, 2007.

The experiment was a 2x3 factorial laid on a randomized complete block design on a plot size of $5x5m^2$. Two level of NPK 20:10:10 fertilizer at 0 and 100 kg ha^{-1} was combined with three levels of cocoa pod ash at 0, 5 and 10 t ha^{-1}. A separate treatment 300 kg ha^{-1} of NPK 20:10:1:10 served as reference control. Treatments were replicated thrice on manually cleared land. Ash was incorporated into the soil. New Roma type of tomato was purchased from a local market. Seedlings were transplanted at 75 x 60cm after three weeks in the nurseries. Weeding was carried out thrice manually and staking was done. Harvest of fruits was done weekly from 8 weeks after sowing; number of fruits and fruits weight were recorded.

Soil analysis

The pH of the soil was determined in 1:1 soil/ water and was read with pH meter. Organic matter was determined by the Walkley and Black (1934) dichromate oxidation method. Total N was determined by using distillation technique (Jackson, 1964) Available phosphorus was extracted by 0.03M NH_4F +0.025M HCl (Bray and Kurtz, 1945) and the phosphorus in the extractant was determined colorimetrically by the blue colouration method on spectronic 20 at 882nm (Murphy and Rilley, 1962). The absorbance (A) taken was calculated to reflect P in mg kg^{-1}.Exchangeable bases (Ca, K and Mg) were extracted with 1N ammonium acetate at pH 7.0. Potassium was read using flame photometer while Ca and Mg were determined AAS. Soil particle size analysis was done by Bouycous (1951) method.

Ash and leaf analysis

The nutrient composition of cocoa husk ash was determined. With the exception of nitrogen (N), the determination of other nutrients was done using wet digestion method based on 25 – 5 – 5 ml of HNO_3 – H_2SO_4 – $HClO_4$ acids (AOAC, 1990). The methods used in soil were also used to analyze P, K, Ca and Mg. Total N was determined with Microkjedahl method.

Leaf samples collected from tomato plants at 50% flowering were oven dried for 24 hrs at 70°C, milled and analyzed as described by Tel and Hagarty (1984).Nutrients determination was carried out as done in cocoa pod ash.

Growth and yield data

Agronomic data were collected on plant basis. Five plants per plot were selected for this purpose. Leaf area was evaluated using graph paper method. Number of fruits and fruit weights were counted and data were transformed using Arkson transformation method.

Statistical analysis

The Duncam Multiple Range Test was used to compare the mean data at 5% level.

Result and discussion

Routine soil analysis indicate that the soil at Adeyemi college of education research farm was acidic, deficient in OM, N, K Ca and Mg but marginal in P. The soil at Fagin was slightly acidic, adequate in Ca, Mg and P, marginal in OM, N and K (Table1)

Relative to control, all the treatments increased soil OM, N, P and K in the two locations. Cocoa pod ash combined with NPK fertilizer, (C5F100, C10F100) had higher ($p<0.05$) soil OM, N, P and K than cocoa pod ash and NPK fertilizer applied individually (Tables 3 and 4). Five and 10 t ha^{-1} of cocoa pod ash (C5F0 and C10F0) released more Ca to the soil than when combined with NPK 20:10:10 fertilizer. Compared with cocoa pod ash applied alone, cocoa pod ash combined with NPK fertilizer reduced Mg at Fagun while Mg was increased at Adeyemi. Soil OM, N, P and K increased as the level of cocoa pod ash and NPK fertilizer increased in the two locations. The low C/N ratio of NPK fertilizer and cocoa pod ash might have enhanced early mineralization of the nutrients present in cocoa pod ash. The increase in soil organic matter, N, P, K Ca and Mg by cocoa pod ash applied individually and cocoa pod ash combined with NPK 20:10:10 fertilizer than 300 kg ha^{-1} NPK 20:10:10 fertilizer might be as a result of the nutrient released by cocoa pod ash.

Tables 5 and 6, show the effect of combined cocoa pod ash and NPK fertilizer on yields of tomato in both locations.

Table 1: initial soil analysis

Location	adeyemi	Fagun
pH	5.60	6.45
Soil organic matter	2.40	2.90
Total N	0.12	0.14
P mg kg^{-1}	7.23	9.15
K c mol kg^{-1}	0.39	0.49
Ca c mol kg^{-1}	1.98	2.10
Mg c mol k^{g-1}	0.90	1.66
Soil physical properties (%)		
Sand	84	44
Silt	11	24
Clay	5	32

Table 2: Nutrient composition of cocoa pod ash (%)

Nutrient	OM	N	C/N	P	K	Ca	Mg
Cocoa pod ash	16.56	1.23	14	1.10	15.52	3.74	2.4

Table 3: Effect of combined cocoa pod ash and NPK fertilizer on soil chemical properties at Fagun (trial 1 and 2)

Treatment	OM	N	P	K	Ca	Mg
	-----%--------		mg kg^{-1} ---------			c mol kg^{-1} -------
C0F0	2.20b	0.12d	7.14c	0.32b	1.00c	0.60b
F300	2.50b	0.13d	8.63bc	0.80b	0.69d	0.52b
C0F100	2.20b	0.12d	7.89c	0.40b	1.00c	0.56b
C5F0	2.90ab	0.15c	9.97b	1.36a	4.10a	1.10a
C10F0	2.80b	0.15c	10.11b	1.59a	4.61a	0.90a
C5F100	3.10a	0.17b	12.20a	1.67a	3.10b	0.69b
C10F100	3.60a	0.19a	13.00a	1.70a	2.99b	0.77ab

Means with the letters are not significantly different at 5% level using DMRT

Table 4: Effect of combined cocoa pod ash and NPK fertilizer on soil chemical properties at adeyemi trial 1 and 2)

Treatment	OM	N	P	K	Ca	Mg
	-----%--------		mg kg^{-1} ----------		c mol kg^{-1} ----------	
C0F0	2.50b	0.13b	7.20c	0.34b	1.98b	1.10a
F300	2.74ab	0.14ab	8.99b	0.93b	1.98b	1.10a
C0F100	2.51b	0.13b	7.21c	0.45b	1.99b	1.10a
C5F0	3.30a	0.16a	10.11ab	1.45a	4.39a	1.14a
C10F0	3.30a	0.16a	10.32a	1.47a	4.00a	0.99a
C5F100	3.32a	0.16a	11.92a	1.73a	3.69a	1.30a
C10F100	3.38a	0.17a	12.00a	1.74a	3.36a	1.30a

Means with the same letters are significantly different at 5% using DMRT

Table 5: Effect of combined cocoa pod ash and NPK 20:10:10 fertilizer on agronomic parameters of tomato at Fagun (trial 1 and 2)

Treatment	No of leaves	No of branches	Leaf area cm^3	No of fruits/plant	Fruit yield/ plant	increase in fruit fruit yield (%)
C0F0	166e	10.50d	19.20e	14.00f	14.50f	0
F300	173de	13.10c	36.30c	27.40e	29.10d	100
C0F100	169e	11.00d	20.00e	16.00f	18.70f	29
C5F0	180d	13.00c	29.00d	30.40d	24.00e	66
C10F0	200c	13.00c	45.00b	34.20c	30.92c	113
C5F100	268b	14.60b	47.10b	38.90b	33.412b	127
C10F100	310a	16.00a	52.20a	42.50a	35.63a	146

Means with the same letters are significantly different at 5% using DMRT

Table 6: Effect of combined cocoa pod ash and NPK 20:10:10 fertilizer on agronomic parameters of tomato at Adeyemi (trial 1 and 2)

Treatment	No of leaves	No of branches	Leaf area cm^3	No of fruits/plant	Fruit yield/ plant	increase in fruit fruit yield (%)
C0F0	324a	11.67a	14..00f	9.00d	10.93c	0
F300	112e	6.67b	30.67c	15.80b	22.70b	108
C0F100	108e	5.67b	17.33e	9.50d	12.00c	10
C5F0	168d	6.67b	24.00d	37.33b	27.80a	154
C10F0	169d	6.80b	40.00b	11.80c	29.40a	169
C5F100	240c	5.67b	37.33b	11.50c	27.90a	155
C10F100	275b	6.00b	46.00a	11.30c	30.01a	175

Means with the same letters are significantly different at 5% using DMRT

Tables 3 and 4 contain mean soil composition as given by cocoa pod ash, NPK fertilizer and their combinations at Fgun and Adeyemi respectively.

At Fagun, relative to control, all the treatments increased the number of leaves, branches, leaf area, no of fruits smaller leaf area, number of fruits and fruit yield. The highest level of combinations (C5F100 and C10F100) had the highest agronomic parameters (Tasble5). Table 6 shows that C10F100 had highest number

of leaves, leaf area and fruit yield. The percentage increases in fruit yield for Fagun were in the order C10F100 > C5F100 > C10F0 > F300 > C0F100 > C0F0 while the increases in Adyeyemi location were C10F100 > C10F0 > C5F100 > C5F0 > F300 > C0F100 > C0F0.
Tables 7 and 8, show the nutrient concentration in tomato tissue at Fagun and Adeyemi respectively and fruit yield. At Adeyemi, the plots without treatments had the highest number of leaves and branches but with lower leaf area, number of fruits per plant and fruit weight.

Table 7: Effect of combined cocoa pod ash and NPK 20:10:10 fertilizer on nutrient composition of tomato/plant at Fagun (trials 1 and 2)

Treatment	N	P	K	Ca	Mg
	----------%				----------
C0F0	2.19b	0.26d	3.08c	0.19d	0.12c
F300	2.44b	0.41c	6.75b	0.17d	0.12c
C0F100	2.24b	0.28d	3.81c	0.19d	0.11c
C5F0	2.91b	0.39c	5.72b	0.39b	0.14b
C10F0	4.48a	0.40c	8.80a	0.67a	0.14b
C5F100	4.14a	0.50b	8.81a	0.31c	0.12c
C10F100	4.16a	0.54a	8.99a	0.30c	0.16a

Means with the same letters are significantly different at 5% using DMRT

Table 8: Effect of combined cocoa pod ash and NPK 20:10:10 fertilizer on nutrient composition of tomato/plant at Adeyemi (trials 1 and 2)

Treatment	N	P	K	Ca	Mg
	----------%				----------
C0F0	1.59e	0.10c	2.72c	0.10c	0.12d
F300	2.10c	0.36b	3.00b	0.12a	0.13d
C0F100	1.86d	0.16c	2.77c	0.10c	0.10d
C5F0	2.36b	0.30b	4.14a	0.98b	0.50a
C10F0	2.39b	0.31b	4.50a	1.12a	0.42b
C5F100	2.96a	0.40a	4.77a	1.00a	0.43b
C10F100	3.10a	0.47a	4.98a	1.00a	0.22c

Means with the s

Relative to control, all the treatments increased leaf N, P, K and Ca (Tables 7 and 8). Cocoa pod ash applied individually (C5F0, C10F0) compared with combined cocoa pod ash and NPK fertilizer (C5F100, C10F100); the combinations had higher N, P and K with lower Ca and Mg (Tables 7 and 8). C10F100 had highest Mg at Fagun while C10F0 had the highest Mg at Adeyemi. C10F0 had highest Ca at both locations compared with other treatrments..

The low fertility status of the soil from both locations especially Adeyemi location was expected to benefit from the treatments applied. Analysis of cocoa pod ash indicates that cocoa pod ash comprised N, P, K, Ca, and Mg. This is in line with the work of Odedina *et al*., 2003, Ayeni *et al*., 2008a and Adu-Dapaah *et al*., 1994, that cocoa pod ash contains plant nutrients The increases in organic matter, N, P, K and Ca contents in the soils treated with cocoa pod ash and its combinations with NPK fertilizers were expected to produce positive response by the tomato plants. The low C/N ratio and the liming effects were expected to aid microbial activities and N and P mineralization (Ayeni *et al.*, 2008b), Allison, 1973). Tomato was expected to perform better in Fagun soil than Adeyemi as a result of higher soil fertility status. The soil treated with cocoa pod ash and its combinations with NPK fertilizer supplied more N, P and K than cocoa pod ash and NPK fertilizer applied individually confirms the findings by Ayeni *et al*., (2008a), Odedina, *et al*., (2003), Ojeniyi *et al*., (2002) that integrated application of cocoa pod ash and NPK fertilizer were more beneficial to soil fertility improvement than their sole application. The least leaf N, P and K found in the tomato planted in the control agreed with the observation that cocoa pod ash supplied N, P and K to the soil. Also, the relatively low leaf N, P and K recorded for tomato grown in soils without treatments compared with the soils amended with combined cocoa pod ash and NPK fertilizer could be attributed to the fact that the control had the least SOM, N, P and K. The better performance of the combined cocoa pod ash and NPK fertilizer was in line with the finding of Olaniyan and Ayodele (1980) that N, P and K strongly influenced the growth and yield of tomato. Nitrogen and P are indispensable for better performance of tomato (Hooper, 1970). The fertilizer combinations produced increased leaf K, Ca and Mg when compared with 300 kg $^{-1}$ NPK 20:10:10 fertilizer in the two locations. This might be as a result of dilution effect as per K (Oladokun, 1986) and low or absence of Ca and Mg in NPK 20:10:10 fertilizer formulation used in these experiments.

Conclusion

Combined cocoa pod ash and NPK 20:10:10 fertilizer increased soil and N, P, K Ca and Mg uptake by tomato plants. This led to significant growth and fruit yield of tomato. The combined application of cocoa pod ash with reduced level of NPK fertilizer was more effective in increasing tomato fruit yield than cocoa pod ash and NPK fertilizer applied individually. Integration of cocoa pod ash and NPK fertilizer had positive effect on soil fertility.

Reference

Adu-Dapaah H.K, J. Combina and E.O. Asare, 1994. Effect of Cocoa Pod ash on maize growth. Journal of Agric. Sc. Cambridge, 132: 31-33.

A.O.A. C., 1990. Official method of analysis. Association of official analytical chemists Washington, D.C.

Allison F.E., 1973. Soil organic matter and its role in crop production, Elsveir Amsterdam, pp. 316-317.

Adu-Dapaah H.K, J. Combina and E.O. Asare, 1994. Effect of Cocoa Pod ash on maize growth. Journal of Agric. Sc. Cambridge, 132: 31-33.

Ayeni L.S., O.M. Ayeni, O.P. Oso and S.O. Ojeniyi, 2008a. Effect of sawdust and wood ash applications in improving soil chemical properties and growth of cocoa (*Theobroma cacao*) seedling in the nurseries. Medwell Agricultuarla Journal, 3(5): 323 -326.

Ayeni L.S., M.T. Adetunji and S.O. Ojeniyi, 2008b. Comparative nutrient release from cocoa pod ash, poultry manure, NPK 20:10:10 and their combinations - Incubation study. Nigerian Soil Science, 18: 23 - 26.

Buoyoucos G.H., 1951. A Recalibration of the Hydrometer for soil testing Mechanical Analysis of Soils. Soil Sci., 59: 45-59.

Carter, M.R., 1993. Soil sampling and method of analysis. Canadian society of soil science, Lewis publishers. pp. 823.

Egunjobi O.A., 1975. Possible utilization of discovered cocoa pod husks fertilizer and nematicide Proc. Interational Cocoa Research conf. Ibadan. Sept., 1 - 9. pp. 541 - 547.

Hooper, L.P., 1970. The basis of fertilizer recordation process. Proceeding of Fertilizer Society. No118. Fertilizer for maximum yield, pp. 250.

Odedina S.A., J.N. Odedina, S. Ayeni, S.A. Arowojolu, S.D. Adeyeye and S.O. Ojeniyi, 2003. Effect of types of ash on soil fertility nutrient availability and yield of tomato and pepper. SSSN., 13: 66-67.

Ojeniyi S.O., O.P. Oso, A.A. Arotolu, 2002. Response of vegetables to wood ash fertilizer. Proceeding of 35th annual conference of Agricultural Society of Nigeria, pp. 33-39.

Olaniyan A. and O.J. Ayodele, 1993. Effect of P on fruit seed of tomato . Report NIHORT, Ibadan, Nigeria, pp. 36 - 39.

Oladokun, M.O., 1986. Percentage composition of cocoa husk, CRIN annual report. Ibadan, Nigeria.

Tel. D.A. and M. Hagarty, 1984. Soil and plant analysis. IITA. Ibadan/ University of Guelph, Ontario, Canada pp. 277.