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Effect of Sawdust and Wood Ash Applications in Improving Soil Chemical Properties and Growth of Cocoa (*Theobroma cacao*) Seedlings in the Nurseries

L.S. Ayeni, O.M. Ayeni, O.P. Oso and S.O. Ojeniyi
Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria

Abstract: Experiments were conducted between 2002 and 2003 in 2 different locations to investigate the effect of sawdust and wood ash applications on soil chemical properties, N and P nutrient content and growth of cocoa seedlings in the nursery. The treatments were 0, 4, 8, 12 and 16 t ha^{-1} of sawdust ash and wood ash replicated 3 times using completely randomized design. The soils used were deficient in organic matter, Mg, Ca and marginal in K and slightly acidic. Ash applied at 4, 8, 12 and 16 t ha^{-1} increased significantly ($p<0.05$) soil available P, exchangeable K, Mg and Ca, leaf N and P contents, number of leaves, plant height and stem girth of cocoa seedlings. The 8 t ha^{-1} of both wood ash and sawdust ash level gave highest increases in growth parameters. Soil total N, exchangeable K, Ca and Mg tended to increase with level of ash.

Key words: Sawdust and wood ash, applications, soil chemical properties, cocoa, nurseries

INTRODUCTION

Cocoa production in Nigeria is limited by soil nutrient depletion. Cocoa seedlings are raised in the nursery using topsoil whereas most soils supporting cocoa are deficient in N and P (Egbe, 1989). Also young seedlings in the nursery and field suffer from macro and micronutrients deficiency due to non-application of Ca, Mg and micronutrients (Omotoso, 1977). In parts of Edo, Delta and Ogun States soils were deficient in cations and acidic. Hence, various trials to determine the effect of fertilizers on cocoa yield showed response to N, P, K and Mg (Ojeniyi, 1981). The soils are particularly limiting in P (Ojeniyi *et al*., 1982).

Cocoa farmers in Nigeria rarely use chemical fertilizers to raise cocoa in the nursery. This can be attributed to high cost and the fact that fertilizer is preferably used on cereal crops that give immediate yield response. It takes minimum of 3 years for improved cocoa varieties to produce pods. There is need to investigate locally sourced agro industrial wastes for raising cocoa seedlings. In Nigeria there has been increase in saw milling industries and hence increase in the amount of sawdust. The sawdust is mostly heaped and burnt into ash. Ojeniyi and Adejobi (2002) and Odedina *et al.* (2003) found that wood ash increased soil P, K, Ca, Mg and yield of vegetables.

Though, there are studies reported on the use of ash for crop production (Odedina *et al*., 2003) there is scarcity of information on the optimum level at which sawdust ash and wood ash can be used to raise cocoa seedlings in the nursery.

The objective of this research was to investigate the effect of sawdust ash and wood ash on growth and nutrient status of cocoa seedlings and soil chemical properties.

MATERIALS AND METHODS

Nursery experiment: Pot experiments were conducted between November 2002 and April 2003 using topsoil collected from Akure and Ondo in rainforest zone of southwest Nigeria. The sandy clay loam soil at both locations is skeletal, kaolinitic and oxic paleustalf. The experiments were sited at the Zonal Office of Ondo State Ministry of Agriculture and Ondo State Agricultural Development Programme, Akure. The cocoa seed used for the experiment was 75c×25c clone hybrid type collected from the Tree Crop Unit of the Ondo State Ministry of Agriculture, Owena. Sawdust ash and wood ash were involved in separate experiments and were separately applied to cocoa seedlings raised in nursery for 6 months at 0, 4, 8, 12 and 16 g bag^{-1} to represent 0, 4, 8, 12 and 16 t ha^{-1}. The size of each polythene bag was 8 cm diameter by 25 cm and each treatment was applied to 4 plants (i.e., 4, 8, 12 and 16 t ha^{-1}) and were replicated 3 times using completely randomized design.

No treatment was applied to the plants with zero treatment to serve as control. Each polythene bag was filled with 2 kg topsoil and seedlings therein were watered 4 times a week by adding 250 cc water. Shade was provided throughout the experiment.

Correponding Author: L.S. Ayeni, Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria

Soil analysis: Bulked topsoil (0-20 cm) samples used for the experiment and those collected per treatment after the experiments were analyzed. Soil samples were air dried and 2 mm-sieved. Total nitrogen was determined using microkjedahl wet oxidation method, available P by Bray-1 method and exchangeable K, Ca and Mg were extracted with ammonium acetate. The K was determined with flame photometer and Ca and Mg by EDTA titration. Soil organic matter was determined by wet dichromate oxidation method. The pH in soil-H_2O 1:2 medium was determined.

The sawdust ash and wood ash were also analyzed. Two grammes of each sawdust ash and wood ash were weighed into dry digestion tube and digested using nitric-perchloric acid mixture to determine P, K, Ca and Mg (Tel and Hagarty, 1984). Total N was determined by microkjedahl method.

Leaf analysis: Leaf samples of treated cocoa seedlings were oven driedat 75°C and ground. Total N was determined using Microckjeldahl method. Ground samples were also digested with Ml HCl, leaf P was determined by molybdenum blue colorimetry, K by flame photometer and Ca and Mg by EDTA titration.

Data collection and statistical analysis: Data on plant height, number of leaves and stem girth were carried out 6 months after planting. The data collected on treatment basis were subjected to analysis of variance and means were compared using the least significant difference ($p<0.05$).

RESULTS AND DISCUSSION

The sawdust ash had 2.5 g kg^{-1} N, 0.1 g kg^{-1} P, 55 g kg^{-1} K, 16 g kg^{-1} Ca and 41 g kg^{-1} Mg and had pH of 9.1. The wood ash had 2.0 g kg^{-1} N, 15.2 g kg^{-1} P and 26.8 g kg^{-1} K, 14 g kg^{-1} Ca and 26.5 g kg^{-1} Mg and had pH of 10. The chemical composition of soil collected from Ondo was organic matter 1.80%, total N 1.2 g kg^{-1}, available P 9.6 mg kg^{-1}, K 0.37 cmol kg^{-1}, Mg 0.50 cmol kg^{-1}, Ca 0.9 cmol kg^{-1} and pH 5.8.The soil collected from Akure had soil organic matter of 0.52%, 0.02 g kg^{-1} total N, 4.33 m g kg^{-1} available P, 0.11 cmol kg^{-1} K, 0.02 cmol kg^{-1} Mg, 1.4 cmol kg^{-1} Ca and pH of 6.1.

According to Egbe (1989) the soil critical level of nutrients for optimum cocoa production are 0.90 g kg^{-1} N, 10 m g kg^{-1} P, 0.30 cmol kg^{-1} K, 5.00 cmol kg^{-1} Ca and 0.80 cmol kg^{-1} Mg. The initial soil analysis indicated that the soils at Ondo were acidic, deficient in Ca and marginal in P. The soil from Ondo was higher in N and K than the critical levels while the soil collected from Akure was deficient in N, P and K.

Table 1 and 2 present data on chemical composition of Ondo and Akure soils as affected by sawdust and wood ash treatments, respectively.

Ash treatments increased soil available P, exchangeable K, Mg and Ca significantly ($p<0.05$) but increases in soil N were not significant.

Exchangeable soil K, total N, exchangeable Mg and Ca tended to increase with amount of ash. The improved soil nutrient contents due to application of ash is consistent with the report of Odedina *et al.* (2003) that application of wood ash increased soil organic matter, N, P, K, Ca and leaf K, Ca and Mg status of tomato. Also, Owolabi *et al.* (2003) found that wood ash treatments applied to soil increased soil organic matter, N, P, K, Ca and Mg contents and leaf K, Ca and Mg status of maize and yam. The increases in soil organic matter and nutrient contents are attributable to the nutrients supplied by the types of ash. The values of soil pH, N, P, Ca and Mg tended to increase with the levels of the 2 type of ash used in the experiment at both sites. This confirms the positive effect of ash on cationic nutrients. These observations are also in agreement with the findings of Folorunsho (1999) who conducted trials in southwest Nigerian soil and found positive responses in the yield and nutrient contents of amaranthus and okra to application of wood ash treatments. The assertion that ash increased soil pH corroborated the findings of Odedina *et al.* (2003) that apart from the ash serving as reservoir of plant nutrients, it also increased the pH of soil, due to abundance of alkaline earth materials. Lalljee also reported that factory ash was effective as a liming material in recycling acidic properties of Florida soils. The increases in soil nutrient contents as a result of addition of sawdust ash and wood ash might also be attributed to enhance microbial activities in soil (Baath and Arnebrant, 1994) and production of organic matter and attendant increased availability of N, P, K, Ca and Mg.

Table 3 below has data on leaf N and P status of cocoa seedlings. The data are mean values of for the 2 experiments in each location.

The 8 t ha^{-1} ash gave the highest leaf N and P status in case of sawdust ash and wood ash experiments. The ash at 4, 8, 12 and 16 t ha^{-1} increased leaf N and P contents of cocoa seedlings compared with the control. The mean leaf N content given by sawdust ash applied at 0, 4, 8, 12 and 16 t ha^{-1} were 6.4, 9.7, 14.1, 12.8 and 11.2%, respectively while the values of N for wood ash were 6.3, 9.3, 11.8, 10.1 and 10.7%. The equivalent values of leaf P given by sawdust ash were 1.4, 1.5, 2.4, 4.4 and 2.2% while wood ash were 1.4, 1.7, 2.0, 1.8 and 1.8%. Therefore, sawdust ash gave higher leaf N and P contents of cocoa seedlings than wood ash. The better effect of sawdust ash might be as a result of higher nutrient content in sawdust ash.

Table 1: Effect of sawdust ash on soil chemical composition at Akure and Ondo

	Akure		Akure		Akure		Akure		Akure		Akure	
Ash	PH	Ondo	N (%)	Ondo	P (mg kg^{-1})	Ondo	K	Ondo	Ca cmol kg^{-1}	Ondo	Mg	Ondo
0	6.0	5.9	0.37	4.70	20.40	29.40	0.14	0.10	1.40	1.33	0.30	0.28
4	7.3	7.1	0.68	0.76	37.60	71.00	0.20	0.18	2.40	2.09	0.50	0.47
8	7.8	7.2	0.87	0.89	68.50	102.00	0.22	0.25	2.80	2.35	0.55	0.54
12	7.8	7.6	0.90	0.94	54.60	71.60	0.27	0.29	2.80	2.43	0.55	0.53
16	7.9	7.8	0.92	1.01	59.80	75.20	0.27	0.32	2.80	2.69	0.60	0.58
LSD (0.05)	0.05	0.03	NS	NS	12.60	12.60	0.02	0.02	0.20	0.04	0.04	0.15

Table 2: Effect wood ash on soil chemical composition at Akure and Ondo

	Akure		Akure		Akure		Akure		Akure		Akure	
Ash (t ha^{-1})	PH	Ondo	N (%)	Ondo	P (mg kg^{-1})	Ondo	K	Ondo	Ca (cmol kg^{-1})	Ondo	Mg	Ondo
0	5.8	7.3	0.42	0.42	25.40	20.90	0.14	0.10	0.90	1.10	0.40	0.29
4	6.7	7.6	0.52	0.67	36.30	39.90	0.20	0.19	0.84	2.04	0.41	0.45
8	7.2	7.7	0.63	0.91	44.90	80.00	0.21	0.19	1.12	2.40	0.66	0.44
12	7.2	7.8	0.69	0.80	42.50	55.00	0.27	0.23	1.25	2.65	0.69	0.52
16	7.2	7.8	0.72	0.95	43.60	69.90	0.27	0.24	1.21	2.99	0.64	0.63
LSD (0.05)	1.00	NS	NS	NS	1.60	4.40	1.01	0.01	0.21	0.25	0.02	0.03

Table 3: Effect of sawdust ash and wood ash on leaf N and P in cocoa seedlings

	N (%)		P (mg kg^{-1})			N (%)		P (mg kg^{-1})	
Sawdust (ash t ha^{-1})	Ondo	Akure	Ondo	Akure	Wood ash t ha^{-1}	Ondo	Akure	Ondo	Akure
0	6.4	6.5	1.5	1.2	0	5.1	7.3	1.5	1.2
4	11.7	7.8	1.8	1.5	4	9.1	9.5	2	1.8
8	15	13.2	2.1	1.9	8	11.8	12	2.7	2.1
12	13.6	11.9	1.9	1.6	12	11.1	9.1	2.5	1.9
16	12	10.4	1.9	1.7	16	10.1	10.8	2.2	2.1
LSD 5%	0.5	3.1	0.1	1.3	LSD 5%	0.5	1.4	0.1	1.3

Table 4: Effect of sawdust ash and wood ash on growth of cocoa seedlings

Ash t ha^{-1}	Plant height (cm)		No. of leaves		Stem girth (cm)	
SDA	Akure	Ondo	Akure	Ondo	Akure	Ondo
0	64.1	69.9	5.7	5.6	7.0	8.5
4	75.1	76.1	6.0	6.5	7.7	9.9
8	94.9	92.8	6.7	6.7	10.2	10.6
12	84.5	77.2	6.2	6.4	8.2	8.6
16	80.6	75.0	6.5	5.8	8.5	8.3
LSD (0.05)	3.05	3.3	0.2	0.3	1.1	1.7
WA						
0	67.9	70.5	5.3	5.4	7.0	7.1
4	73.7	77.9	5.8	5.7	8.0	7.9
8	96.3	90.2	6.2	6.4	10.2	10.0
12	85.4	78.8	6.1	6.0	8.3	8.3
16	80.9	80.7	6.0	5.9	8.7	7.0
LSD 0.05	2.85	2.42	0.4	0.2	1.2	0.4

Relative to the control, 8 t ha^{-1} of sawdust ash gave 117 and 43% increases in leaf N and P, respectively while wood ash gave 87 and 71% increases in leaf N and P. Therefore, ash more improved leaf N status compared with leaf P. These findings are consistent with earlier findings of Owolabi *et al.* (2003), Odedina *et al.* (2003) and Folorunsho (1999) that types of ash increased leaf nutrient content of tomato and other vegetables..

Table 4 contains data on growth parameters of cocoa. The ash treatments at 4, 8, 12 and 16 t ha^{-1} increased seedling height, number of leaves and stem girth relative to the control irrespective of the type of ash used. The 8 t ha^{-1} types of ash gave the highest increases in the growth parameters. The finding that 8 t ha^{-1} gave highest increases in value of seedling height, number of leaves and seedling girth can be related to the finding that the treatments mostly increased the N and P contents of cocoa seedlings.

CONCLUSION

Application of sawdust ash and wood ash to soil that contained cocoa seedlings increased soil nutrient contents, leaf N and P status and growth parameters of cocoa seedlings. Ash is found to be effective source of nutrients for young cocoa plants. It is recommended for use at 8 t ha^{-1} to maximize growth of seedlings and nutrient status.

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