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Full Length Research Paper

Soil nutrients and cocoa seedling performance as influenced by plant residue ash and NPK fertilizer addition on a depleted soil in Ibadan, south western, Nigeria

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Abstract

A trial on Soil nutrients and Cocoa seedling performance as influenced by plant residue ash and NPK 20:10:10 fertilizer addition on a depleted soil in Ibadan was conducted at the greenhouse of Cocoa Research Institute of Nigeria, Ibadan, Southwest, and Nigeria. Five treatments comprising of control, 10kgN/ha of NPK 20:10:10, and oil palm bunch ash (OPA) at 4, 6, 8 t /ha were applied to six weeks old cocoa seedlings. The treated pots in four replicates were arranged in a completely randomized design (CRD). Watering was carried out thrice a week for six months and data on growth parameters taken on monthly basis. The dry matter yield was determined after oven drying of the harvested seedlings to a constant weight at 70 ^{o}C for 72 hours. The OPA applied at 6t/ha increased soil OM, N, P, Ca, and Mg relative to control. Soil pH value was increased significantly ($p< 0.05$) by OPA compared to NPK 20:10:10 and control. The organic nutrient source at 6t/ha was significantly better than the control and compared favorably well with NPK 20:10:10 for optimal Cocoa seedlings performance for all the growth parameters and dry matter yield (DMY) considered. It is therefore recommended that cocoa farmers could substitute NPK fertilizers which could be injurious to the soil environment, pollute underground water and reduce market values of cocoa products for organic residue which is environmentally friendly, harmless to consumers, cheap and readily available.

Keywords: Cocoa seedling, NPK, oil palm bunch ash, parameters.

INTRODUCTION

Crop production in Nigeria is sustained mainly by nutrients derived from organic sources and bush fallow. However, the maintenance of organic matter in soil is a major problem especially in semi arid and arid zones, where there is high demand for organic and agricultural wastes (Ojeniyi, 2010).Large quantities of human, agricultural, forestry and industrial wastes are produced annually which are not being effectively utilized. However, because of increasing costs of chemical fertilizers coupled with disposal problems posed by these wastes, their use as means of maintaining organic matter level and boosting agricultural productivity has become an economic proposition. Studies have shown that ash derived from wood, cocoa pod husk, saw dust, oil palm bunch and other plant sources increased availability of nutrients in the soil and crop respectively thereby causing a significant increase in yield of food crops such as vegetables, maize, yam, cassava e .t .c (Olomilua, *et al*., 2007; Ojeniyi *et al.,* 2007; 2010; Ezekiel et al., 2009b and Ayeni *et al.,* 2008a). Although, Oil palm bunch has been found to be an effective source of fertilizing and liming materials, its influence on growth and performance of cocoa seedlings have not yet received adequate research attention. Despites the huge economic importance of cocoa to the nations' economy, its production is hampered by low field establishment rate within the first three years, due to inadequate and or imbalance of the soil nutrient status, scarcity and high cost of inorganic fertilizer.

The use of NPK and any other in- organic fertilizer to supply needed amount of nutrients to cocoa farm land is presently too costly and very expensive for poor resource Nigerian farmers (Ojeniyi *et al.*, 2010). Also, continual usage of in organic fertilizers over a long period result to soil, air, and water pollutions (Giles, 2005).The use of organic fertilizer is described to be cheap, environmentally friendly and safe. Oil palm bunch ash is one of the many farm wastes reported to be of good nutrient sources for arable crops in Nigerian agriculture. It has been used to advantage for crop like Maize and Amaranths (Owolabi *et al.,* 2003; Ojeniyi *et al.,* 2010) but it is yet to be used for the production of cocoa. The objective of this present study therefore was to determine the effect of Oil palm bunch ash and NPK 20:10:10 fertilizer on chemical properties of soil, growth performance, and dry matter yield of Cocoa seedlings under green house.

MATERIALS AND METHODS

A green house study to determine the effects of soil nutrients and Cocoa seedling performance as influenced by plant residue ash and NPK 20:10:10 fertilizer at cocoa Research Institute of Nigeria (C.R.I.N), Ibadan in the rainforest zone of southwest Nigeria. Depleted soil (0-15cm) was collected bulked, air dried and passed through a 2mm sieve. The experiment was laid out in a completely randomized design (CRD) with five treatments replicated four times. These include: Control (no application), Oil palm bunch ash (OPA) at 4, 6 and 8t/ha and 10kg N/ha of NPK 20:10:10 fertilizer. Three fresh cocoa beans were planted per pot containing 10kg soils which were later thinned to one (the most vigorous) per pot three weeks after sprouting. Treatments were introduced to the plants in a ring form one month after sprouting when most of the available nutrients in the soil have been utilized by the crop. Watering was carried out thrice a week for six months. Weeding was done as when due. Agronomic data such as plant height, girth, number of leaves, number of branches and leaf area were monitored monthly for a period of six months.

Pre and Post Soil analysis

Prior to the commencement of the experiment, soil samples (0-15cm) were collected, air dried ground and sieved using 2 mm sieve mesh. They were chemically analyzed as described by Tel and Hagarty (1984). Organic matter was determined by wet oxidation method through chronic acid digestion. Nitrogen was determined by micro kjeldahl approach; available P was extracted by Bray-1 solution and determined using the spectro - photometric method. Exchangeable K, Ca and Mg were extracted using ammonium acetate; K was determined using flame photometer; Ca and Mg by EDTA titration method. Soil pH in ratio 2:1 water suspension was determined using a glass electrode on EIL 7020 pH meter. Representative soil samples were collected per pot at the end of the experiment and subjected to chemical analyses as described above. Statistical analysis was performed using Duncan's multiple range test (DMRT), and means separated using Least Significance Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Data on nutrients composition of the soil and organic materials used for the trial are shown on Table 1. The soil is slightly acidic, low in organic matter (OM); total N; available P; exchangeable K; and Ca. The organic carbon (OC); of 10.30g/kg was below the 30g/kg ideal for suitable soil for tree crop production, and suggests the need to increase the soil organic matter(OM) content in other to allow for optimal and sustainable cropping on the soil. The soil N content of 0.76g/kg was far below the critical value of 1.0g/kg while the P value of 5.8mg/kg was moderate. The K, Ca and Mg contents of 0.18; 4.15 and 0.68 $Cmolkg^{-1}$ respectively were all below the soil critical values of 1.2; 8.0 and 0.80$Cmolkg^{-1}$ soil respectively for Kola plants (Egbe *et. al.* 1989). The oil palm bunch ash on the other hand, contained 0.17%N; 0.12%P; 26.3%K; 6.19%Ca; 3.00%Mg; 1.70% OC respectively. However, the alkaline nature of the fertilizing materials was expected also to correct the slightly acidity of the soil.

The soil nutrient contents as influenced by OPA and NPK 20:10:10 fertilizer is presented in Table 2. OPA at all levels and NPK increased the soil N, P, K, Ca, Mg and OM significantly ($p< 0.05$). Soil N increased with increase rate of OPA, the NPK 20:10:10 fertilizer gave the highest values of N and P (0.91 and 17.24g/kg) relative to control (0.56 and 4.95 g/kg). The increases in soil nutrients due to NPK and OPA can be adduced to increased soil OM which might have been due to enhanced microbial activity. The improved soil nutrients content as a result of application of ash is in agreement with the findings of Ayeni *et al.* (2008b) who reported that addition of wood ash to soil increased its OM, N, P, K and Ca. Similarly, Ayeni *et al.* (2009) also found that ash derived from cocoa pod husk increased soil nutrients. Relative to control, application of OPA at all levels significantly increased the soil pH with highest soil pH values (7.85) recorded at 6t/ha. There were no significant treatment effect between OPA at 6t/ha and 8t/ha respectively since similar results were recorded for both (Table 2). However, the effects of NPK 20:10:10 on soil pH and Mg were not significant compared with the control. The increases in soil OM and nutrient content is consistent with the observation on the composition of OPA. As from 4t/ha, OPA increased pH which confirms its liming effect due to

Table 1. Nutrients composition of the soil and organic materials used for the trials

Materials	N (g/kg)	P (g/kg)	K (g/kg)	Ca (Cmol/kg)	Mg (Cmol/kg)	Om (g/kg)	pH (H2O)
Soil	0.76	5.80	0.18	4.10	0.68	17.75	6.4
O P A (%)	0.17	0.12	26.3	6.91	3.00	2.93	8.31

OPA = Oil palm ash

Table 2. Soil nutrients content as influenced by OPA and NPK 20:10:10 fertilizer

Fertilizer	N (g/kg)	P (g/kg)	K (g/kg)	Ca (Cmol/kg)	Mg (Cmol/kg)	OM (g/kg)	pH ($Cacl_2$)
OPA (t/ha)							
4	0.63^{b}	14.41^{b}	0.30^{c}	4.80^{b}	0.81^{b}	16.40^{b}	6.70^{b}
6	0.80^{a}	17.01^{a}	0.56^{a}	5.41^{a}	1.05^{a}	18.11^{a}	7.85^{a}
8	0.79^{ab}	16.90^{a}	0.51^{a}	$5\ 30^{ab}$	1.04^{a}	17.57^{a}	7.70^{a}
$10kgNha^{-1}$ of							
NPK 20:20:20	0.91^{a}	17.24^{a}	0.45^{b}	4.48^{c}	0.55^{c}	16.23^{bc}	6.23^{bc}
Control	0.56^{c}	4.95^{c}	0.20^{d}	4.31^{c}	0.51^{c}	10.66^{c}	6.34^{c}

Means in the same column denoted by same letters are not significantly different (p< 0.05)

Table 3. Growth parameters and dry matter yield (g/plant) of cocoa seedlings as influenced by OPA and NPK 20:10:10 fertilizer six month after planting

Fertilizer	Height (cm)	girth (cm)	Leaf No	Branch No	Leaf area	Dry matter yield
OPA (t/ha)						
4	55.00^{c}	1.50^{b}	40.00^{bc}	4.10^{bc}	100.00^{c}	51.00^{c}
6	70.20^{a}	1.70^{a}	55.50^{a}	5.60^{a}	130.50^{a}	58.53^{a}
8	58.80^{b}	1.11^{c}	39.00^{c}	4.10^{bc}	80.00^{d}	50.50^{c}
NPK 20:10:10	50.80^{d}	1.00^{c}	42.50^{b}	4.41^{b}	105.50^{b}	54.15^{b}
Control	38.60^{e}	0.90^{d}	25.35^{d}	2.40^{c}	75.50^{e}	26.17^{d}

Means in the same column denoted by same letters are not significantly different (p< 0.05)

high contents of K, Ca ad Mg. The values of soil pH, OM, N, P, K, Ca, and Mg tended to be increased with levels of OPA especially at 6t/ha. This attests to the additive effect of OPA on soil nutrients content. An earlier study of Ikpe *et al.* (1997) attributed increased available P in soil with application of OPBA to release of P from complexes of Al and Fe under increasing soil pH. They also found that OPBA increased soil pH.

Table 3 present data on growth parameters and dry matter yield of cocoa seedlings as influenced by OPA girth, number of leaves per plant and number of branches relative to control. There was a slight decrease in all the growth parameters considered when the rate of application exceeded 6t/ha. Up to 6t/ha of OPA, dry matter yield and leaf area increased significantly ($p < 0.05$) compared with the control and NPK 20:10:10 fertilizer. The mean dry matter yield increases given by 4, 6, 8 t/ha OPA and NPK 20:10:10 fertilizer were 21.2%, 24.4%, 21.0% and 22.5% respectively.

This work shows that OPA increased soil nutrient contents and this effect led to significant increase growth performance of cocoa seedlings and dry matter yield of the crop. Ash treatments also had liming effect on the soil by increasing soil pH. However, the result is in conformity with findings of Ikpe et al. (1997) that OPBA increased rice yield, soil pH and Available P. 20:10:10 fertilizer treatments increased significantly ($p > 0.05$) and NPK 20:10:10 fertilizer treatments. OPA and NPK plant height,

CONCLUSION

The results of the present study revealed that Oil palm bunch ash (OPA) contained Ca, Mg and other essential micro nutrients in addition to N,P,K . Similarly, its addition enhanced cocoa seedling growth, dry matter accumulation and improved the soil nutrient status. Therefore, it could be recommended as soil amendment for a depleted soil.

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