Relative efficacy of cocoa pod husk-based compost on growth and nutrient uptake of cocoa seedlings in the nursery

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ABSTRACT

The effect of cocoa pod husk-based compost on growth and nutrient uptake of cocoa seedlings was compared with conventional NPK 15-15-15 fertilizer at the nursery in a randomized complete block design experiment. Poly bags were filled with either top soil or compost alone, and also with mixtures of top soil, compost and inorganic fertilizer in various ratios to provide the following treatments: soil alone, compost alone, 1 : 1 soil/compost, soil + fertilizer, 1 : 1 soil/compost + fertilizer, 1 : 2 soil/compost, 1 : 2 soil/compost + fertilizer, 2 : 1 soil/compost, 2 : 1 soil/compost + fertilizer. The fertilizer was added at the rate of 6 g per poly bag. Plant height, girth, leaf area, dry matter yield, and root volume of cocoa seedlings were significantly (P<0.05) affected by the potting media at 24 weeks after sowing. Potting media with the fertilizer additions significantly (P<0.05) produced shorter seedlings with smaller stems and narrower leaves. Root volumes and total dry matter yield of seedlings positively correlated (r = 0.733), and were significantly (P<0.05) higher in soil/compost mixtures than in treatments with fertilizer additions. Irrespective of the potting media, the uptake of N by the seedlings was higher than P and K. However, the addition of fertilizer to the potting media with compost resulted in lower N uptake by the seedlings. The use of compost developed from cocoa pod husk as potting medium or soil amendment for nursing cocoa seedlings enhanced better seedling growth than when used in combination with NPK 15-15-15 fertilizer.

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Introduction

In Ghana, the medium used for nursing cocoa seedlings in poly bags, the recommended nursery practice (Manu & Tetteh, 1987), is the 'black soil' collected from the refuse dump.

In recent times, farmers use different types of soils for filling the poly bags in nursing cocoa seedlings because of the scarcity of the black soil. This practice often adversely affects the growth of the seedlings because of the poor fertility levels of the soils (Donkor, Hendersen & Jones, 1991). With the cocoa rehabilitation programme in Ghana now, many farmers are being encouraged to either cultivate new cocoa farms or expand existing farms, which often requires establishing large nurseries. Therefore, the need is to search for appropriate medium for nursing healthy cocoa seedlings. Improving the fertility status of top soils through adding any form of soil amendments could be one of the ways of enhancing proper growth of the seedlings at the nursery. Ahenkorah *et al.* (1973) and Ofori-Frimpong, Afrifa & Appiah (2006a) have demonstrated the improvement in the growth of cocoa seedlings in the nursery by using organic soil amendments. Cocoa pod husk is readily available and has high nutrient content (Atanda & Egbe, 1964). Preparing compost from the pod husk may be expensive in terms of time, and could affect the quantity produced. Although Ofori-Frimpong *et al*. (2006a) observed growth depression in cocoa seedlings that received fertilizer at the time of sowing the seeds, the need is to explore the possibilities of combined use of organic materials such as cocoa pod husk compost and inorganic soil amendments in improving the potting media for nursing cocoa.

This paper reports on the comparative effects of cocoa pod husk-based compost and conventional NPK 15-15-15 fertilizer on the growth and nutrient uptake of cocoa seedlings in the nursery.

Materials and methods

The experiment was conducted in the nursery at the Cocoa Research Institute of Ghana (CRIG). Surface soil (0-15 cm), Rhodi-lixic ferralsol (WRB, 1998) was collected from an experimental farm of CRIG, Tafo.

Compost preparation

Cocoa pod husk-based compost was prepared as described by Ofori-Frimpong *et al*. (2006b). Four wooden stacks were driven into the ground on a flat land in an area of 1 m × 1 m to serve as the corners of the compost heap. Fresh cocoa pod husk (200 kg) and trash (30 kg) were chopped into pieces and the materials spread on the ground as the first layer after which 400 kg top soil was added. This was repeated in succession until the height was 1 m. Water was sprinkled on each layer before the next layer was laid. The layers were turned at 4 and 8 weeks of composting to ensure adequate aeration and decomposition of materials. The heap was broken after 12 months and the composted materials were stored under cover.

Laboratory determinations

The *p*H of soil and compost was determined on 1:2.5 soil to water ratio by glass electrode method. Other chemical analyses included organic carbon (Tinsley, 1950), total nitrogen by the Kjeldahl digestion method (Bremner,1965), available phosphorous determined by the method of Truog (1930), and exchangeable potassium after extracting it with 1M ammonium acetate solution on Varian Atomic Absorption Spectrophotometer. Table 1 presents some properties of the soil and compost used.

TABLE 1

Some Properties of Soil and Compost Used in the Experiment

Property	*Soil*	*Compost*
*p*H (H_2O 1 : 2.5)	6.23	nd
Organic C (%)	2.80	3.36
Total N (%)	0.243	0.366
Available P (mg kg^{-1})	32.6	91.1
Exchangeable K (cmol $^{(+)}$ kg^{-1})	0.19	6.12

nd = not determined

Poly bags of size 18 cm × 25 cm, perforated at the base were filled with soil, compost and NPK 15-15-15 fertilizer mixture at different ratios by weight as indicated below:

T_1 Top soil alone (S)
T_2 Compost alone (C)
T_3 Soil + 6 g NPK 15-15-15
T_4 1 : 1 S/C
T_5 1 : 1 S/C + 6 g NPK 15-15-15
T_6 1 : 2 S/C
T_7 1 : 2 S/C + 6 g NPK 15-15-15
T_8 2 : 1 S/C
T_9 2 : 1 S/C + 6 g NPK 15-15-15

Soil and compost were 3 kg weight each. The fertilizer rate of 6 g NPK 15-15-15 per bag was based on an earlier studies that indicated better growth of cocoa seedlings at that rate compared to higher rates.

Three seeds of cocoa of mixed varieties were planted in each bag. Emerged seedlings were thinned to one stand per bag 20 days after sowing. The bags were watered as and when necessary to keep the soil moist. Monthly height, girth, and leaf area of the seedlings were recorded for 24 weeks. Root volume was determined by immersing the root system in a calibrated beaker of water and subtracting the initial volume of water in the beaker from the volume of water plus root. Seedling dry weight was determined after drying in an oven at 80 °C to a constant weight. Total N and P in the plant were determined by the methods of Bremner (1965) and Cavell (1965) respectively, while K was determined on Varian Atomic Absorption Spectrophotometer after acid digestion. Data were analysed statistically (ANOVA) and treatment means were compared by the Least Significant Difference method.

Results and discussion

Vegetative growth

Plant height, girth, and leaf area of the seedlings were significantly (P<0.05) affected by the different potting media at 12 and 24 weeks (Table 2). However, the seedlings grown in the soil + fertilizer mixture (T_4) performed poorer than those planted in potting media with compost addition. In the soil + fertilizer mixture medium, seedlings were significantly (P<0.001) shorter with smaller girth than in the soil or compost alone medium at 24 weeks after sowing. The unamended soil (T_1) produced seedlings with smaller leaf sizes that were significantly (P<0.05) different from the amended soil and compost alone treatments. The 1 : 1 S/C medium recorded significantly (P<0.05) highest leaf area. The trend in the growth of the cocoa seedlings in relation to the potting media corroborates the earlier observations on the use of inorganic fertilizers at the time of planting cocoa beans in the nursery (Ofori-Frimpong *et al*., 2006a). The results also confirmed earlier observations by Acquaye *et al*. (1962) and Ahenkorah *et al*. (1973) that conventional fertilizers should be applied during the time of planting cocoa with caution, and if possible discouraged. The better performance of cocoa seedlings grown in potting media of soil and compost mixtures may be attributed to reduction in the bulk density of soil due to adding the compost, which encouraged better root development.

Dry matter production and root volume of cocoa seedlings

Table 3 presents the mean total dry matter yield and root volume of the seedlings at 24 weeks after sowing. The differences in the dry matter yield among the treatments were significant (P<0.05) with the higher values recorded for the soil/compost mixtures alone. Similarly, soil/compost mixtures alone produced significantly larger root volumes than in the treatments with fertilizer additions. Better root proliferation,

TABLE 2

Effect of Potting Media on Some Growth Parameters of Cocoa Seedlings

Treatment	*12 weeks*			*24 weeks*		
	Height (cm)	*Girth (mm)*	*Leaf area (cm^2)*	*Height (cm)*	*Girth (mm)*	*Leaf area (cm^2)*
Soil alone (S)	36.5	4.8	31.0	60.2	7.8	61.0
Compost alone (C)	34.6	4.9	39.0	71.1	8.0	74.0
1 : 1 S/C	40.3	4.2	35.0	65.0	8.5	90.0
Soil + Fertilizer	29.9	4.1	33.0	50.6	7.0	63.0
1 : 1 S/C + Fertilizer	34.4	4.4	38.0	71.3	7.6	78.0
1 : 2 S/C	43.7	6.5	45.0	71.8	7.7	64.0
1 : 2 S/C + Fertilizer	38.2	6.1	48.0	71.8	7.7	64.0
2 : 1 S/C	44.1	6.1	48.0	71.8	7.7	64.0
2 : 1 S/C + Fertilizer	38.6	4.7	37.0	67.9	7.4	69.0
LSD (0.05)	2.36	0.88	2.83	2.48	0.87	3.6

which encouraged higher root volume in soil/compost alone media, might have encouraged more vigorous shoot growth. Total dry matter yield significantly ($P<0.05$) correlated positively ($r = 0.733$) with the root volumes of the seedlings.

Nutrient uptake

Table 4 presents the absolute amounts of N, P and K calculated as the product of the nutrient concentration and plant weight of the seedlings at 24 weeks after sowing. Relative to the soil + fertilizer treatment (T_4), adding the fertilizer to the soil/compost mixtures resulted in lower uptake of N by the seedlings. In contrast to the observation for N, there were increases in the uptake of P and K by the seedlings after adding the fertilizer. A possible reason for the lower uptake of N by the seedlings in the presence of the compost may be immobilization of N in the fertilizer by the compost. It is also possible that enzyme activity for the mineralization of organic nutrients in the compost was inhibited, because Appiah, Halm & Ahenkorah (1985) observed heavy metals such as lead and copper in cocoa pod husk ash. Lesser root proliferation, resulting in the smaller root volumes of cocoa seedlings in compost-amended soils (Table 3), could also affect the uptake of nutrients. Therefore, higher P uptake by the seedlings may reflect the initial high P of the soil used for the study (Table 1).

TABLE 3

Effect of Potting Media on Dry Matter Yield and Root Volume of Cocoa Seedlings at 24 Months After Planting

Treatment	*Dry matter (g)*	*Root volume (cm^3)*
Soil alone (S)	11.0	11.5
Compost alone (C)	11.5	10.0
1 : 1 S/C	14.6	12.7
Soil + Fertilizer	9.6	8.2
1 : 1 S/C + Fertilizer	10.2	9.8
1 : 2 S/C	16.6	12.2
1 : 2 S/C + Fertilizer	10.3	7.8
2 : 1 S/C	12.1	9.5
2 : 1 S/C + Fertilizer	9.1	8.8
LSD (40 df)	1.7	2.7

TABLE 4

Total Nutrient Uptake (mg) by Cocoa Seedlings of 24 Weeks After Sowing

Treatment	*N*	*P*	*K*
Soil alone (S)	215.0	18.9	15.1
Compost alone (C)	108.0	38.5	29.7
1 : 1 S/C	229.0	18.4	18.1
Soil + Fertilizer	242.0	22.8	23.2
1 : 1 S/C + Fertilizer	181.0	38.4	29.7
1 : 2 S/C	200.0	30.6	17.1
1 : 2 S/C + Fertilizer	231.0	30.5	24.7
2 : 1 S/C	146.0	24.5	14.4
2 : 1 S/C + Fertilizer	171.0	34.2	23.2
Mean	191.4	28.5	21.7
SE $\pm$	14.8	3.1	1.9

Conclusion

Growth of cocoa seedlings raised by the poly bag method in soil/compost mixtures of 1 : 1 and 1 : 2 ratios were significantly better than those planted in the mixture with addition of NPK fertilizer at the nursery. The depressive effect of conventional fertilizer on growth of cocoa seedlings at the nursery reported earlier (Ofori-Frimpong *et al.*, 2006a) has been confirmed.

Growth of seedling girth was enhanced in the soil/compost mixture. Glendining (1960) studied the relationship between growth and yield in cocoa and established a high positive correlation between pre-bearing growth rates and yield. It may, therefore, be suggested that cocoa seedlings that had better growth in the soil/compost mixture alone may be preferable for planting in the cocoa rehabilitation programme.

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