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Interactions of Soil Amendments and Complex Fertilizers II: Effects on the Growth of Cocoa Seedlings *(Theobroma cacao* L.*)*

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Key words: Soil amendments; complex fertilizers; growth effects; *Theobroma cocoa* **L.)**

RINGKASAN

Timbal-balas pembaikan-pembaikan tanah dan baja kompleks ke atas tumbesaran anak benih koko (Theobroma cacao *L.) telah dikaji dengan percubaan faktorial. Parameter-parameter tumbesar; ketinggian tanaman, lilitan batang, banyak daun dan luas permukaan daun ditentukan selang empat minggu sehingga lapan belas minggu. Hasil berat kering daun, batang, akar dan jumlah kesemuanya ditentukan di akhir kajian ini.*

Penaburan satu-satu jenis bahan ini tidak menggalakkan tumbesaran anak benih koko. Tetapi, penggunaan GML bersama baja kompleks akan meningkatkan dengan jelas ketinggian tanaman, lilitan batang, banyak daun dan luas permukaan daun apabila dibandingkan dengan kawalan. Akibat-akibat yang sama diperolehi bagi hasil-hasil bahan kering. Pengapuran sahaja memperbaiki pembentukan akar tetapi tidak bagi hasil bahan kering tampang. Anak benih yang dirawat dengan Agrosil sahaja menunjukkan tumbesaran tergencat dan hasil bahan kering berkurangan. Keadaan ini diperbaiki dengan penggunaan baja-baja kompleks 12 : 12 : 17 : 2 + TE dan 16 : 18 : 12 : 5 + TE.

SUMMARY

*Interactions of soil amendments and complex fertilizers on the growth of cocoa seedlings (*Theobroma cacao *L.) were examined by means of a factorial trial. The growth parameters – plant height, stem diameter, leaf number and leaf area were assessed at intervals of four weeks up to eighteen weeks. The dry matter yields of leaf, stem, root and their sum were determined at the end of the experiment.*

Individual applications of the materials used did not enhance growth of cocoa seedlings. However, incorporation of GML and complex fertilizers significantly increased plant height, stem diameter, leaf number and leaf area when compared to the control. Similar effects were obtained for dry matter yields. Liming alone improved root development but not the vegetative dry matter yields. Agrosil treated seedlings showed stunted growth and reduced dry matter yields. The above conditions were improved by the applications of complex fertilizers 12 : 12 : 17 : 2 + TE and 16 : 18 : 12 : 5 + TE.

INTRODUCTION

The advent of nursery practice has given rise to the problems of potting medium and fertilizer application for cocoa seedlings. These have prompted extensive studies in this field throughout the major cocoa producing countries (Wood, 1980).

At present, two methods are generally used to improve the potting medium, that is, liming (Teoh, 1978) and changing the ratios and composition of the medium (Ahenkorah and Halm, 1976).

Contradictory reports, however, have been made concerning the judicious use of fertilizers. Teoh and Ramadasan (1978) reported that compound fertilizers did not promote growth. However, the response of cocoa seedlings to fertilizers under inland soils as potting media has been widely reported in Malaysia (Mainstone *et al.*, 1973, Teoh, 1978). The current recommended nursery practice requires a fortnightly application of complex fertilizer (Teoh, 1978) which results in high labour costs.

It is clear that more suitable forms of soil amendments and complex fertilizers are required

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for cocoa seedlings. This has stimulated the conduct of the present study at the Agronomy Experimental Plot at Universiti Pertanian Malaysia. This paper discusses the preliminary results of the study in determining the use of Agrosil[1] and slow-release complex fertilizers in a cocoa nursery.

MATERIALS AND METHODS

This experiment is similar to the one described in Part 1 of this study (Shahbuddin and Goh, 1983). In addition, vegetative measurements were recorded at intervals of four, eight, twelve and eighteen weeks after planting. Seedling height was measured from the cotyledon scar to the stem extremity while stem diameter was taken at 1 cm above the cotyledon scar (Teoh, 1978). Leaf area was calculated from the leaf length data based on the general equation derived by Asomaning and Lockard (1963). At the end of the experiment, dry matter yields were taken which were further divided into dry weights of leaf, stem and root. The treatments and notations used were the same as that presented in Table 1 of Part 1 of this study (Shahbuddin and Goh, 1983).

RESULTS AND DISCUSSION

Vegetative growth

Fertilizer and soil amendment incorporations resulted in significant growth as shown in Table 1. However, their interactions were not statistically significant except for leaf area. This finding concurred with the results obtained by Teoh (1978). The growths as measured by the plant height, stem diameter and leaf area showed a rapid increase after the twelfth week for all treatments as presented in *Figures 1* and *2*. These exponential growth responses were mainly due to physiological and climatic factors (Thong and Ng, 1978).

Plants treated with fertilizers were significantly taller after twelve weeks. This was in agreement with the results reported by various workers (Wessel, 1969; Santana *et al.*, 1977; Teoh, 1978). Similarly, girth development was enhanced by fertilizer incorporation as presented in Table 1. On the other hand, liming alone did not promote plant growth which contradicted the findings of Mainstone *et al.*, (1973) and Teoh (1978). This was mainly due to the low nutrient status of the potting medium (Shahbuddin and Goh, 1983). Thus, upon the addition of complex fertilizers, plant growth was significantly improved (Table 1).

Negative growth response was obtained by seedlings treated with Agrosil alone. This could be ascribed to the nutritional imbalances as presented in Part 1 of this study (Shahbuddin and Goh, 1983).

That fertilizer supplements can remedy the conditions after the twelfth week is exemplified by *Figures 1* and *2*. Results obtained at the end of the experiment showed that only seedlings treated with liming and fertilizers had significantly larger stem diameters compared with other treatments (Table 1).

The leaf area was significantly affected by fertilizers, amendments and their interactions. At fourth week after planting, it was observed that liming and 12 : 12 : 17 : 2 + TE complex fertilizers gave a significantly higher leaf area while agrosil reversed the situation. These were maintained throughout the experiment except for seedlings treated with lime alone which showed a lower rate of increase in leaf area at the later stage *(Figure 2)*. Similar results were observed by Teoh (1978) for the liming and complex fertilizer treatments. The aggravating effect of Agrosil was possibly due to nutritional disorder. It was also observed that 12 : 12 : 17 : 2 + TE complex fertilizer was more effective than 16 : 8 : 12 : 5 + TE complex fertilizer in promoting leaf area. This was probably due to the higher total N applied in the case of 12 : 12 : 17 : 2 + TE complex fertilizer and its faster release rate. It is also interesting to note that although Agrosil treated seedlings had similar a leaf number as lime treated seedlings, they had a smaller leaf area. This implies that leaf size is reduced with Agrosil treatment.

The application of fertilizers significantly increases the total leaf number whereas soil amendments do not have any significant effect. The increase in leaf number due to application of fertilizer was also reported by Teoh (1978). However, liming did not increase leaf production when complex fertilizers were not incorporated. This result differed from that obtained by Teoh (1978). Agrosil treatments resulted in premature abscission of leaves as shown in Table 2. This effect was reduced when complex fertilizers were applied. This implies that the problem was mainly due to nutritional disorder as discussed in Part 1 of this study (Shahbuddin and Goh, 1983).

Existing leaf number showed a similar trend as the total leaf number except at the eighteenth week where interaction gave a significant effect.

[1] Agrosil is a registered soil conditioner in the Republic of Germany and consists of $Na_2S_1O_3$ and P_2O_5 (20%).

TABLE 1
Effects of treatments on plant height, stem diameter and leaf area (mean values)

Treat-ments	4 weeks			8 weeks			12 weeks			18 weeks		
	Plant height (cm)	Stem diameter (mm)	Leaf area (cm^2)	Plant height (cm)	Stem diameter (mm)	Leaf area (cm^2)	Plant height (cm)	Stem diameter (mm)	Leaf area (cm^2)	Plant height (cm)	Stem diameter (mm)	Leaf area (cm^2)
GO	10.70	2.17	143.19	13.32	3.22	373.36	16.77	4.18	658.80	27.16	5.50	1225.05
GN	11.27	2.25	146.81	13.91	3.45	464.50	19.05	4.61	939.05	32.94	6.42	2070.00
GT	11.48	2.25	157.56	14.52	3.29	427.18	20.08	4.38	861.14	33.27	6.36	1709.70
AO	10.68	2.14	87.36	12.27	2.97	271.63	13.94	3.62	551.28	21.85	4.71	890.93
AN	10.85	2.14	107.38	12.85	3.09	321.41	17.24	3.95	727.74	29.98	5.77	1490.29
AT	11.18	2.20	108.41	12.87	3.04	376.34	16.89	3.88	696.12	28.40	5.58	1353.62
OO	10.81	2.14	133.43	13.13	3.01	365.82	16.18	4.03	594.19	25.52	5.45	1127.64
ON	11.73	2.23	150.87	14.27	3.36	430.51	18.34	4.09	872.33	29.96	5.80	1625.77
OT	10.63	2.17	133.14	13.45	3.16	422.24	16.97	4.15	821.10	27.19	5.39	1262.68
$LSD_{0.05}$	n.s.	n.s.	14.40	1.07	0.19	34.13	1.28	0.23	64.47	3.10	0.42	213.42
$LSD_{0.01}$			22.42	1.67	0.30	53.15	1.99	0.36	100.37	4.83	0.66	332.29

n.s. – denotes non-significant difference at $\alpha = 0.05$.

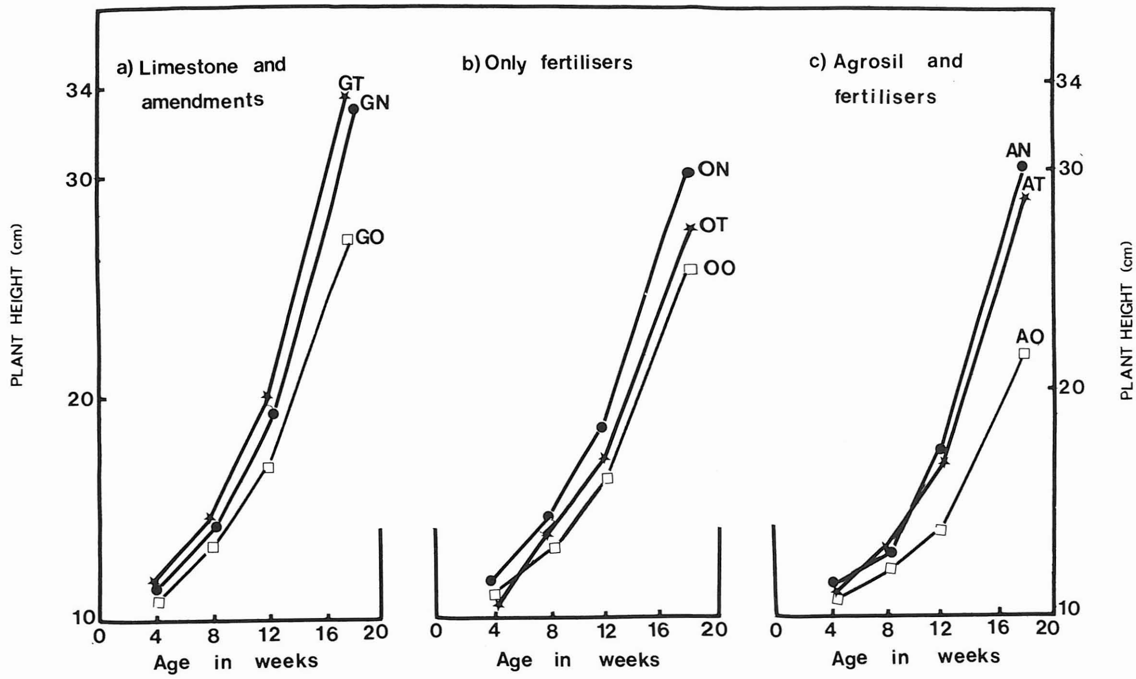

Fig. 1. Effects of amendments and complex fertilizer incorporation on plant height.

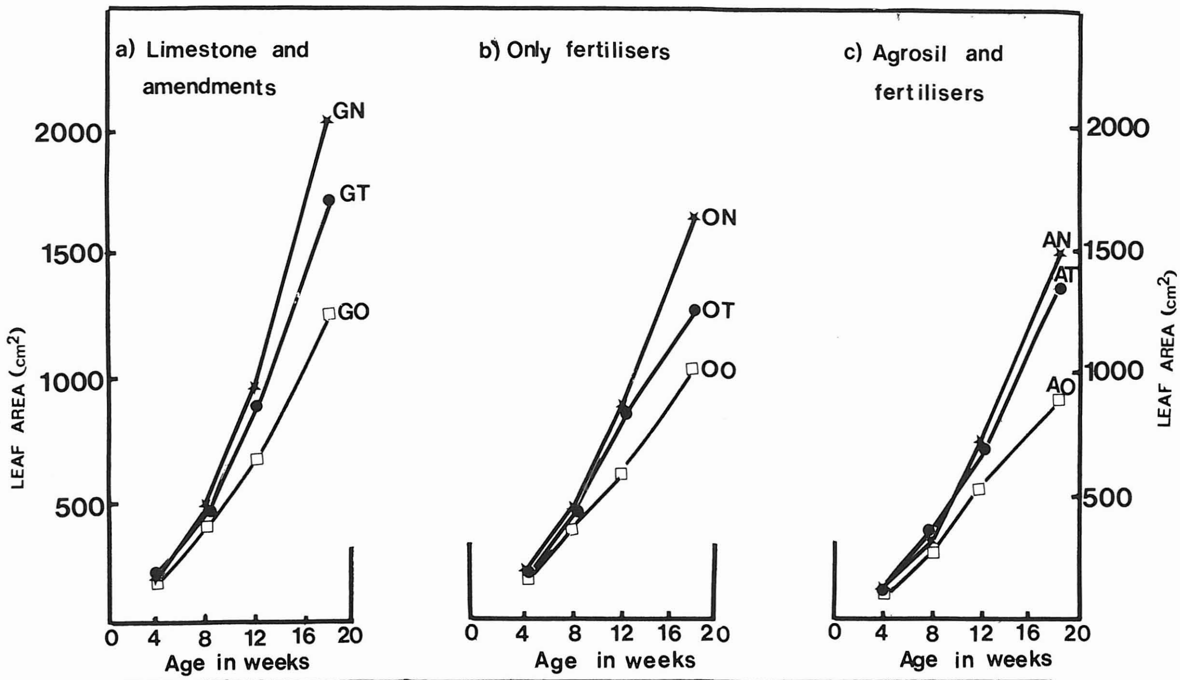

Fig. 2. Effects of amendments and complex fertilizer incorporation on leaf area.

This was probably caused by two factors; firstly, an increased premature abscission of leaves in seedlings treated with Agrosil alone and secondly, a remarkable recovery of seedlings supplemented

TABLE 2
Effects of treatments on average leaf number of seedlings

Treatments	4 weeks	8 weeks	12 weeks Existing	12 weeks Total	18 weeks Existing	18 weeks Total
GO	4.9	10.2^{ab}	13.8^{c}	13.8^{c}	18.9^{bc}	19.9^{d}
GN	5.2	11.2^{a}	15.5^{ab}	15.5^{ab}	22.6^{a}	22.6^{ab}
GT	5.1	10.7^{ab}	15.2^{abc}	15.2^{ab}	23.6^{a}	23.6^{a}
AO	5.3	9.8^{b}	12.0^{d}	12.9^{d}	12.9^{d}	17.8^{d}
AN	5.2	11.1^{a}	15.7^{a}	15.7^{a}	23.2^{a}	24.8^{a}
AT	5.5	10.9^{ab}	15.3^{abc}	15.4^{ab}	20.2^{b}	21.6^{b}
OO	5.0	9.8^{b}	14.0^{bc}	14.0^{c}	18.2^{c}	18.2^{d}
ON	5.5	10.6^{ab}	15.7^{a}	15.7^{ab}	22.8^{a}	22.8^{ab}
OT	5.2	10.9^{ab}	15.0^{abc}	15.0^{b}	20.0^{bc}	20.0^{cd}

Same letters in each column show non-significant difference at $\alpha = 0.05$.

with fertilizers apart from Agrosil incorporation. Hence, their differences in leaf numbers were amplified.

Dry matter yields

It was observed that the dry weight of shoot was significantly influenced by fertilizers and amendments but not their interactions. The results also showed that liming increased the dry weight of shoot, provided fertilizers were applied (Table 3). This contradicted with the results obtained by various researchers (Boynton and Erickson, 1954; Wryley-Birch, 1969; Morais *et al.,* 1972). It also suggests low soil nutrient content to be a greater limiting factor. However, it was found that fertilizer supplements alone did not promote vegetative growth. This implies that the lowered soil pH which might have reduced the availability of nutrients and reduced root development (Table 3), would hinder shoot growth also. Thus, a balance between the soil pH and nutrient contents must be maintained for vigorous growth of cocoa seedlings. Apart from this, Agrosil and Agrosil with fertilizer treatments produced similar effects on the dry weight of shoot as they did on the other parameters which were discussed in the preceeding section.

The dry weights of stem and leaf followed similar trends as observed for dry weight of shoot (Table 3). However, the dry matter yield of root was significantly influenced by soil amendments only. Liming was observed to promote root development. This was probably due to an increase in Ca content in the soil (Murray, 1966), a reduction of Al content (Santana *et al.,* 1973; Ezeta *et al.,* 1979) or both. The improved root development provided an obvious advantage due to the non-vigorous root system of cocoa (Smyth, 1965). Such an advantage was not exhibited when the soil was not supplemented with fertilizers as illustrated by seedlings treated with lime alone (Table 3). Thus, the total dry matter yields were influenced by soil amendments to a larger extent as reported by Teoh and Ramadasan (1978) and presented in Table 3. The trend observed was repeatedly similar to that for dry weight of shoot. (Response of cocoa seedlings in terms of total dry matter yield was obtained for lime plus fertilizer treatments only while Agrosil alone reduced the dry matter yield). The 12 : 12 : 17 : 2 + TE complex fertilizer did not provide any significant increase in dry matter yield over the 16 : 8 : 12 : 5 + TE complex fertilizer when used in combination with the same amendments.

CONCLUSION

The experiment shows that cocoa seedlings have a high nutrient requirement. Thus, Serdang series soil is not suitable as a potting medium unless supplemented by both liming and complex fertilizers. Results also indicate that the slow-release fertilizer which was applied at a lower

TABLE 3
Effects of treatments on the mean dry matter yields

Treatment	Leaf (g)	Stem (g)	Shoot (g)	Root (g)	Total
GO	5.10^{bc}	2.24^{bc}	6.34^{cd}	2.39^{d}	9.72^{b}
GN	7.06^{a}	3.39^{a}	10.45^{a}	2.24^{ab}	12.69^{a}
GT	6.44^{ab}	3.27^{a}	9.71^{ab}	2.43^{a}	12.15^{a}
AO	3.37^{d}	1.42^{d}	4.79^{e}	1.40^{d}	6.19^{c}
AN	5.71^{bc}	2.58^{b}	8.29^{bc}	1.90^{bc}	10.20^{b}
AT	5.54^{bc}	2.47^{bc}	8.00^{cd}	1.65^{cd}	9.65^{b}
OO	4.53^{cd}	2.02^{c}	6.55^{d}	1.80^{cd}	8.35^{d}
ON	5.72^{bc}	2.16^{bc}	7.88^{cd}	1.89^{bc}	9.77^{b}
OT	4.90^{c}	2.08^{bc}	6.97^{cd}	1.62^{cd}	8.80^{b}

rate and only once may be a good substitute for 12 : 12 : 17 : 2 + TE complex fertilizers.

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