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Effect of using sub soil with organic materials as a substitute to top soil in potting medium of rubber nurseries

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Abstract

The study examined the influence of sub soil with organic material or materials compared to top soil on the growth of Hevea seedlings. Substitution of top soil with sub soil and five locally available organic materials on growth and nutrient contents of the rubber plants (Hevea brasiliensis) during nursery stage were studied. Only top soil was used as control treatment (T1). The experiment was included nine treatments and the combinations of the treatments were arranged in a completely randomized block design with twenty replicate plants. Plant growth parameters viz; diameter, height, leaf area and plant dry matter accumulation were measured periodically at the end of before and after budgrafting stages. Macro nutrient concentrations in leaves of the after budgrafting plants were determined to assess the nutritional status of the plant. Improved growth assessments; plant height, leaf area, plant dry matter accumulation and enhanced leaf nutrient contents could be observed with the treatment having sub soil and organic materials such as coir dust, poultry and refuse tea. Almost all growth assessments (94%) and all leaf nutrient contents (100%) related to sub soil with organic materials; coir dust or poultry or refuse tea or coir dust and poultry treatments gave significantly higher or no significant effect compared to top soil (T1). Deterioration of growth assessments; plant height, leaf area and plant dry matter accumulation could be observed with the treatments having sub soil and organic materials such as paddy husk and saw dust. All growth assessments (100%) related to sub soil with organic materials; paddy husk or saw dust or poultry and paddy husk or poultry and saw dust treatments gave significantly lower or no significant effect compared to top soil (T1). In general, many occasions (93%) leaf nutrient contents in sub soil + organic material or materials gave significantly higher or no significant effect compared to top soil (T1). It is evident from results that significantly higher many growth parameters associated with sub soil with coir dust could be accepted as a superior medium for polybag plants compared to the RRI recommended top soil only potting medium. Moreover, sub soil with refuse tea or poultry could be used as a substitute for top soil only medium without any failure.

Key words: dry matter, *Hevea brasiliensis*, leaf nutrients, organic materials, seedling plants

Introduction

Rubber is a perennial crop grown for latex which is the economically important product given by the plant. Thirty years life cycle is remaining this tree crop including three growth stages named nursery, immature and mature. Nursery stage is very important and the production of healthy planting material is an important aspect for the plantation industry in Sri Lanka. Currently this nursery plants are maintained in polybag at about eight months and after that stage it has to be planted under field conditions. Rubber Research Institute of Sri Lanka (RRISL) recommends to fill polybags of rubber nursery plants with top soil and this condition may help to manage optimum soil fertility throughout the nursery stage of rubber. Presently, the unavailability of fertile top soil directly affects the fertility management of polybag nursery plant. Fertile top soil can be substituted by sub soil with organic material is one of the best option to cater this problem in an environmental friendly manner. Hettiarachchi (2002) observed that the less fertile subsoil could be improved by the application of organic materials. Locally available organic materials are mainly originated from the wastes and residues of plant and animal life. Yogaratnam and Silva (1987) observed the importance of the use of organic manures in rubber fields and some locally available organic sources such as cow dung, poultry and pig dung were identified as fertilizers. Organic manures play an increasingly important role in sustainable cultivation of *Hevea* and optimize the productivity of the soil for *Hevea* cultivation, and consequently obtain higher growth and yield (Yogaratnam, 2000). Numerous workers observed that the performances of rubber plants could be improved as results of improvement of soil fertility by the application of organic sources (Samarappuli *et al*., 1998; Samarappuli, 1995; Amarasiri and Wickramasinghe, 1978; Amarasiri and Wickramasinghe, 1977). However, information in this aspect is not well documented.

The aim of this study was to evaluate the effectiveness of organic materials with sub soil as a substitute for top soil on growth of rubber seedling plants in polybags.

Material and Methods

Top soil and sub soil were collected from the upper 15 cm and 15 cm below from the surface of the soil respectively. These soils represent a great soil group of red yellow podzolic (RYP) soils classified as Ultisols according to the FAO-USDA system. Soil was air dried, stubbles and root particles were removed by hand and crushed gently to pass through 2 mm sieve. Basic properties of such soils were given in Table 1. Five locally available organic materials which were used in the experiment were air dried and passed through 2 mm sieve. This experiment was included nine treatments and the combinations of the treatments are given in Table 2 and were arranged in a completely randomized block design with twenty replicate plants.

Potting mediums were prepared according to the experimental design in Table 2 and was thoroughly mixed with 50 g of higher grade Eppawala Rock Phosphate (HERP) according to the RRISL recommendation for rubber nursery plant. These bags were placed in shallow trenches. Germinated seeds were placed one seed per bag and watered daily in dry weather to keep the soil moist. The systemic fungicides were sprayed regularly to keep the plants disease free (Fig. 1). Plants were fertilized according to the RRISL recommendation for rubber nursery plants (Advisory circular, fertilizer to rubber 2009). Recommended quantities of N, P, K, Mg fertilizer mixtures were dissolved in water and applied as 50 ml of the solution per bag at 2 weeks intervals. Compared to inorganic fertilizers, organic materials which were used the experiment had low nutrient values.

Table 1. *Properties of top soil and sub soil used in the experiment*

Property	Top soil	Sub soil
pH	4.5	4.8
Organic carbon (%)	1.35	1.15
Total N (%)	0.15	0.097
Available P (ppm)	28	19
Exchangeable K (ppm)	58	20
Exchangeable Ca (ppm)	55	45
Exchangeable Mg (ppm)	15	10

Table 2. *Treatment combination of the experiment*

Treatment	Design of potting mediums	Ratio
1	Top soil only	-
2	Sub soil + Coir dust	1 : 1
3	Sub soil + Paddy husk	1 : 1
4	Sub soil + Poultry	2 : 1
5	Sub soil + Saw dust	1 : 1
6	Sub soil + Saw dust + Poultry	1 : 1 : 1
7	Sub soil + Paddy husk + Poultry	1 : 1 : 1
8	Sub soil + Coir dust + Poultry	1 : 1 : 1
9	Sub soil + Refuse tea	1 : 1

Fig. 1. Rubber seedlings were grown in polybags under field conditions

Growth assessments

Height and diameter assessments were made at 13 weeks after planting and 16 weeks after budgrafting. At the time of 13 weeks after planting and 16 weeks after budgrafting randomly selected four replicates from each treatment, were harvested and separated into components and their dry weights were recorded by drying the components at 105^0C in an oven for constant weight except leaves and leaves were dried at 60^oC for constant weight. Before drying the components leaf area measurement was made using a portable type leaf area meter.

Plant analysis

Fully matured, all leaves from each plant were collected for assessment of mineral nutrient concentration of leaves (RRIM 1971b).

Statistical analysis

Statistical analysis of the experimental data was done by analysis of variance followed by a mean separation procedure, Duncan's Multiple Range test (DMRT), at a probability level of 0.05.

Results and Discussion

The assessments of plant diameter, height, leaf area, dry matter accumulation of seedlings were made before budgrafting at the end of 13 weeks after commencement of the experiment is given in Table 3. Plant height, leaf area, root and shoot dry matter accumulations were significantly higher at before bud grafting stage in sub soil + coir dust treatment (T2) compared to those in top soil (T1). Moreover, only the plant height and shoot dry matter accumulation were significantly higher in sub soil + poultry treatment (T4) compared to those in top soil (T1). All growth parameters were measured at before bud grafting stage in sub soil + coir dust + poultry treatment (T8) and sub soil + refuse tea treatment (T9) did not show any significant differences compared to those in top soil (T1). The shoot and root dry matter accumulations were significantly lower at before bud grafting stage in sub soil +

paddy husk treatment (T3), sub soil + saw dust treatment (T5), sub soil + saw dust + poultry treatment (T6), sub soil + paddy husk + poultry treatment (T7) and another growth parameter; plant height was significantly lower only in sub soil + saw dust + poultry treatment (T6) compared to those in top soil (T1).

The assessments of plant height, leaf area, root and shoot dry weight of scion were made at the end of 16 weeks after budgrafting is given in Table 4. All growth parameters, plant height, leaf area, root and shoot dry matter accumulations which were measured at after bud grafting stage were significantly higher in sub soil + coir dust treatment (T2) compared to those in top soil (T1). Except plant height other growth parameters were significantly higher in sub soil + refuse tea treatment (T9) compared to top soil (T1). All growth parameters in sub soil + paddy husk + poultry treatment (T7); shoot and root dry matter accumulation in sub soil + saw dust + poultry treatment (T6), leaf area and root dry matter accumulation in sub soil + poultry treatment (T4), shoot dry matter accumulation in sub soil + saw dust (T5) and sub soil + paddy husk treatment (T3) were significantly lower compared to those in top soil (T1) (Table 4).

Table 3. *Effect of different soil combinations on growth of Hevea seedlings at before budgrafting stage*

Treatment	Dia. (mm)	Height (cm)	Leaf area (cm^2)	Root Dry Wt.(g)	Stem Dry Wt.(g)
(T1)Top soil only	6.6^{ab}	62.1^{b}	1170^{bcd}	4.27^{bc}	6.27^{b}
(T2)Sub soil + Coir dust	7.2^{a}	68.4^{a}	1464^{a}	5.4^{a}	7.77^{a}
(T3)Sub soil + Paddy husk	6.35^{b}	59.88^{bc}	1287^{abc}	3.12^{e}	5.47^{cd}
(T4)Sub soil + Poultry	6.85^{ab}	67.93^{a}	1415^{ab}	4.7^{b}	7.55^{a}
(T5)Sub soil + Saw dust	6.475^{ab}	59.57^{bc}	1086^{cd}	3.9^{d}	5.27^{c}
(T6)Sub soil + Saw dust + Poultry	6.225^{b}	55.67^{c}	1104^{cd}	3.35^{de}	4.77^{d}
(T7)Sub soil + Paddy husk + Poultry	6.55^{ab}	57.75^{bc}	954^{d}	3.07^{e}	3.82^{e}
(T8)Sub soil + Coir dust + Poultry	6.825^{ab}	68.6^{bc}	1296^{abc}	4.52^{bc}	6.5^{b}
(T9)Sub soil + Refuse tea	6.75^{ab}	68.6^{bc}	1258^{abc}	4.67^{b}	6.77^{b}

Values in the same column followed by the same letter are not significantly different at p=0.05.

Table 4. *Effect of different soil combinations on growth of Hevea seedlings at after bud grafting stage*

Treatment	**Height (cm)**	**Leaf area (cm^2)**	**Root Dry wt.(g)**	**Stem Dry Wt.(g)**
(T1) Top soil only	57.05^{bc}	2544^{bc}	16.07^{cd}	9.65^{b}
(T2) Sub soil + Coir dust	63.4^{a}	2973^{a}	21.35^{a}	12.35^{a}
(T3) Sub soil + Paddy husk	57.15^{bc}	2440^{bcd}	15.87^{cd}	8.15^{cde}
(T4) Sub soil + Poultry	54.85^{cd}	2050^{e}	13.07^{e}	8.7^{bcd}
(T5) Sub soil + Saw dust	60.25^{abc}	2526^{bc}	16.5^{bc}	7.47^{e}
(T6) Sub soil + Saw dust + Poultry	54.75^{dc}	2284^{cde}	10.77^{f}	5.02^{f}
(T7) Sub soil + Paddy husk + Poultry	49.95^{d}	2196^{de}	13.3^{e}	7.12^{e}
(T8) Sub soil + Coir dust + Poultry	62.4^{ab}	2322^{cd}	16.3^{bc}	9.2^{bc}
(T9) Sub soil + Refuse tea	58.0^{abc}	2922^{a}	17.45^{b}	11.52^{a}

Values in the same column followed by the same letter are not significantly different at p=0.05.

Several workers observed that the performance of rubber plants could be improved as a result of improvement of soil fertility by the application of organic residues as a mulching material (Samarappuli, 1995; Samarappuli *et al*., 1998; Amarasiri and Wickramasinghe, 1988; Amarasiri and Wickramasinghe, 1977). The better establishment of seedlings and vigorous growth of plants could be attributed to the improvement of the environment around the root zone as a result of addition of organic sources (Joshi *et al*., 1982). Allmaras & Nelson, 1971 and Chaudhary & Prihar (1974) reported that organic mulching induced density of rooting and greater lateral spread of roots. Varying degrees of significance of correlations were obtained between the application of different organic materials and their response of growth of seedling plants (Dharmakeerthi *et al*., 2009; Meng *et al.,* 2018; Goswami *et al*., 2017; Kadoglidou *et al*., 2014; Maja *et al*., 2017; Adekiya and Agbede, 2017).The beneficial effect of organic amendment for seedling might have helped in uptake of water and nutrients and thereby improving the growth of seedling plants.

Similar effects such as improved growth assessments; plant height, leaf area and plant dry matter accumulation could be observed with the treatments which were having sub soil and organic materials such as coir dust, poultry and refuse tea. Almost all growth assessments (94%) except only two occasions, sub soil with organic material; coir dust or poultry or refuse tea or coir dust and poultry treatments gave significantly higher or no significant effect compared to top soil.

Nutrient contents of leaves were measured at after bud grafting stage in Table 5. Results showed that leaf Mg contents were significantly higher in all treatments which were included sub soil and organic material or materials compared to top soil (T1). Significantly higher growth parameters were observed in sub soil + coir dust treatment (T2), sub soil + poultry treatment (T4) and sub soil + refuse tea treatment (T9) gave significantly higher leaf N, P and Mg contents compared to top soil (T1). Only the sub soil + paddy husk treatment (T3) and sub soil + saw dust treatment (T5) gave significantly lower values of leaf N compared to top soil (T1). In general, many occasions (93%) leaf nutrient contents in sub soil + organic material or materials gave significantly higher or no significant effect compared to top soil (T1). It has been reported that soil nutrient levels for N, P, K and Mg in *Hevea* are reflected by the leaf nutrient levels (Yew and Pushparajah, 1984; Guha and Yew, 1966; Tan, 1972). Accordingly application of organic material or materials with subsoil enhanced nutrient availabilities in soils and their effect could be observed as enhancement of leaf nutrient contents in different treatments. Organic materials differ considerably in their ability to supply nutrients to the soil and crop. These differences are related to the decomposition and nutrient release rates and patterns, which are in part controlled by resource quality of the materials (Paul, 2016). Organic material contains above the critical level C:N ratio of about 20:1, microorganisms absorb nutrients from the soil solution, occur net immobilization. When the C:N ratio falls below the critical 20:1 ratio, nutrients are excreted by microorganisms and become available to the plant (Paul and Clark, 1989). Organic materials with low lignin and poly phenol contents decompose rapidly, have high direct nutrient effect (Xu *et al*., 2017; HE *et al*., 2016; Fox *et al*., 1990; Palm and Sanchez, 1991).

Table 5. *Effect of different soil combinations on leaf nutrient contents of rubber seedling plants*

Treatment	N%	P%	K%	Mg%
(T1) Top soil only	3.61^{b}	0.268^{cd}	1.102^{c}	0.181^{d}
(T2)Sub soil + Coir dust	3.72^{a}	0.313^{b}	1.132^{c}	0.244^{b}
(T3)Sub soil + Paddy husk	3.172^{d}	0.28^{cd}	1.144^{c}	0.217^{c}
(T4)Sub soil + Poultry	3.83^{a}	0.315^{b}	1.095^{c}	0.261^{a}
(T5)Sub soil + Saw dust	3.42^{c}	0.264^{d}	1.104^{c}	0.226^{c}
(T6)Sub soil + Saw dust + Poultry	3.69^{b}	0.309^{b}	1.196^{b}	0.221^{c}
(T7)Sub soil + Paddy husk + Poultry	3.85^{a}	0.352^{a}	1.199^{b}	0.223^{c}
(T8)Sub soil + Coir dust + Poultry	3.68^{b}	0.341^{a}	1.301^{a}	0.249^{ab}
(T9)Sub soil + Refuse tea	3.76^{a}	0.292^{b}	1.111^{c}	0.246^{ab}

Values in the same column followed by the same letter are not significantly different at p=0.05.

Considering all growth assessments and leaf nutrients, its seems to suggest that organic materials such as coir dust, poultry and refuse tea were decomposed rapidly and gave favourable effect similar or better to good fertile top soil for growing seedling plants in the polybags. However, organic materials such as saw dust and paddy husk were resistant to decompose and failed to give favourable effect similar to above. Coir dust also has high C:N ratio and decomposition of coir dust might accelerate with application of chemical fertilizers.

Successful establishment of rubber in the field is achieved by young budding poly bag plants. Top soil of clay loamy mixture should be used for filling these polybags. In Sri Lanka about 5000 ha is replanted annually with new planting materials, in order to maintain the 30 year planting cycle. For this purpose 12000 MT of top soil is required annually for filling bags. Scarcity of fertile top soil for filling purposes and continuous application of same soil in their surrounding areas may create less fertile conditions in the potting medium of polybag plants. These conditions may lead the production of unhealthy planting materials. Accordingly, selected some of the organic materials could be used advantageously with sub soil as a substitute for top soil for filling bags.

Conclusion

In this study it was observed comparable or better plant parameters with sub soil accompanied with selected organic materials compared to top soil. It can therefore be concluded there is a possibility of using organic materials such as coir dust, poultry and refuse tea with sub soil as a substitute for top soil for the filling medium of rubber seedling plants.

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