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EFFECT OF SOIL MOISTURE ON ESTABLISHMENT SUCCESS OF DIFFERENT PLANTING TECHNIQUES IN RUBBER

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ABSTRACT

Effects of soil moisture on establishment success and early growth of rubber plants were studied by comparing the performance of five establishment practices under four levels of soil moisture. The growth of brown budded poly bag plants was found to be superior to other establishment practices such as green budding polybags, young budding polybags, brown budded bare roots and green budded bare roots. In general, the plants raised in polythene bags appear to have an initial advantage over the use of bare root budded stumps. However, with adequate amount of soil moisture the subsequent growth of all types of buddings after establishment were comparable.

At low soil moisture levels, brown budded bare root plants showed the highest plant diameter and height in comparison with the other establishment practices. Plant spread, number of whorls and leaf area of brown budded polybag plants were found to be superior to other establishment practices. As would be expected better growth resulted in higher total dry weight of brown budded polybag plants even under low soil moisture level of 10% available water.

Similar results were obtained in relation to root spread, root length and root dry weight. Data on nutrient contents also showed that brown budded polybag plants had the highest plant nitrogen and potassium contents under very low soil moisture levels. Moreover, leaf phosphorus content was highest in brown budded polybag plants. Similar to the results observed with some growth parameters, micro–tapped yield of brown budded polybag plants was higher than under other establishment practices.

An important finding that emerges form this study is that brown budded polybag plants would be the best among the currently used planting techniques for use under unfavorable environments in relation to soil moisture.

Key words: *Hevea brasiliensis*, soil moisture, establishment practices

INTRODUCTION

Efficient methods of establishment and maintenance of young rubber during the early years in the field are important in order to obtain a full, uniform stand that would grow vigorously and reach the productive stage as early as possible. During recent years there have been few developments in the method of establishment of rubber plants in the field (Yahampath, 1969; Hurov, 1960; Sergeant, 1967; Leong and Yoon, 1985).

Adequate availability of soil moisture during field establishment is considered important for establishment success, and therefore planting is normally done with the monsoonal rains. But the establishment success in the field is liable to be poor if dry weather follows transplanting. Even in wet regions, dry spells are common and prolonged drought periods also occur in marginal rubber growing areas with distinct dry seasons. These adverse weather conditions lead to soil moisture stress which adversely affects the establishment success and early growth of young rubber plants. Since irrigation is not feasible on the type of land where rubber is normally grown, a study of the effects of moisture on establishment success and early growth of plants grown under different establishment practices was undertaken in order to identify establishment practices that would be most suitable for areas under moisture stress.

MATERIALS AND METHODS

A pot experiment was done to compare the effects of soil moisture on the performance of different establishment practices of *Hevea*, at Dartonfield, Agalawatta. Five different establishment practices were tested under four levels of moisture in a fully randomized design with single tree plots replicated three times.

Four levels of moisture (M) are :

- M_0 – Watering at 90% depletion of available water
- M_1 – Watering at 70% depletion of available water
- M_2 – Watering at 50% depletion of available water
- M_3 – Watering at 30% depletion of available water

Five different establishment practices (E) are:

E_1	-	Brown budded bare roots
E_2	-	Green budded bare roots
E_3	-	Brown budded poly bags
E_4	-	Green budded poly bags
E_5	-	Young budded poly bags

A field nursery of stock seedlings was established to prepare green buddings and seedlings in a 15 months old stock nursery were used to prepare brown buddings. To prepare young buddings, seedlings were planted in polybags and budded with clone RRIC 121. One-whorled poly bag plants and bare root budded stumps were planted in empty barrels where both lids were removed. The barrels were buried in the soil leaving a 4 inch rim above the soil. Each barrel was lined with polyethylene sheets and was filled with soils of *Agalawatta* series (Silva, 1964), sieved with a one inch sieve and the barrels were buried in a plant house with a transparent roof and cloth curtains around it to prevent interference by rain water during the heavy rainy periods. N,P,K and Mg fertilizers were applied uniformly according to RRISL recommendations. Growth measurements, plant nutrient contents, plant physiological measurements and micro-tapped yield were recorded periodically.

RESULTS

Assessment of plant diameter made at the end of 3 and 6 months after planting indicated that there was a significant difference ($P<0.001$) between different establishment practices in plant diameter (Table 1). Plant diameter made at 9 and 12 months after planting showed that there was a significant interaction ($P<0.01$) between different establishment practices and soil moisture regimes (Fig.1). At low soil moisture levels, brown budded bare root plants showed the highest plant diameter in comparison with the other establishment practices. At higher levels of soil moisture, this difference narrowed down, showing a significantly lower diameter only in plants with green budded bare roots.

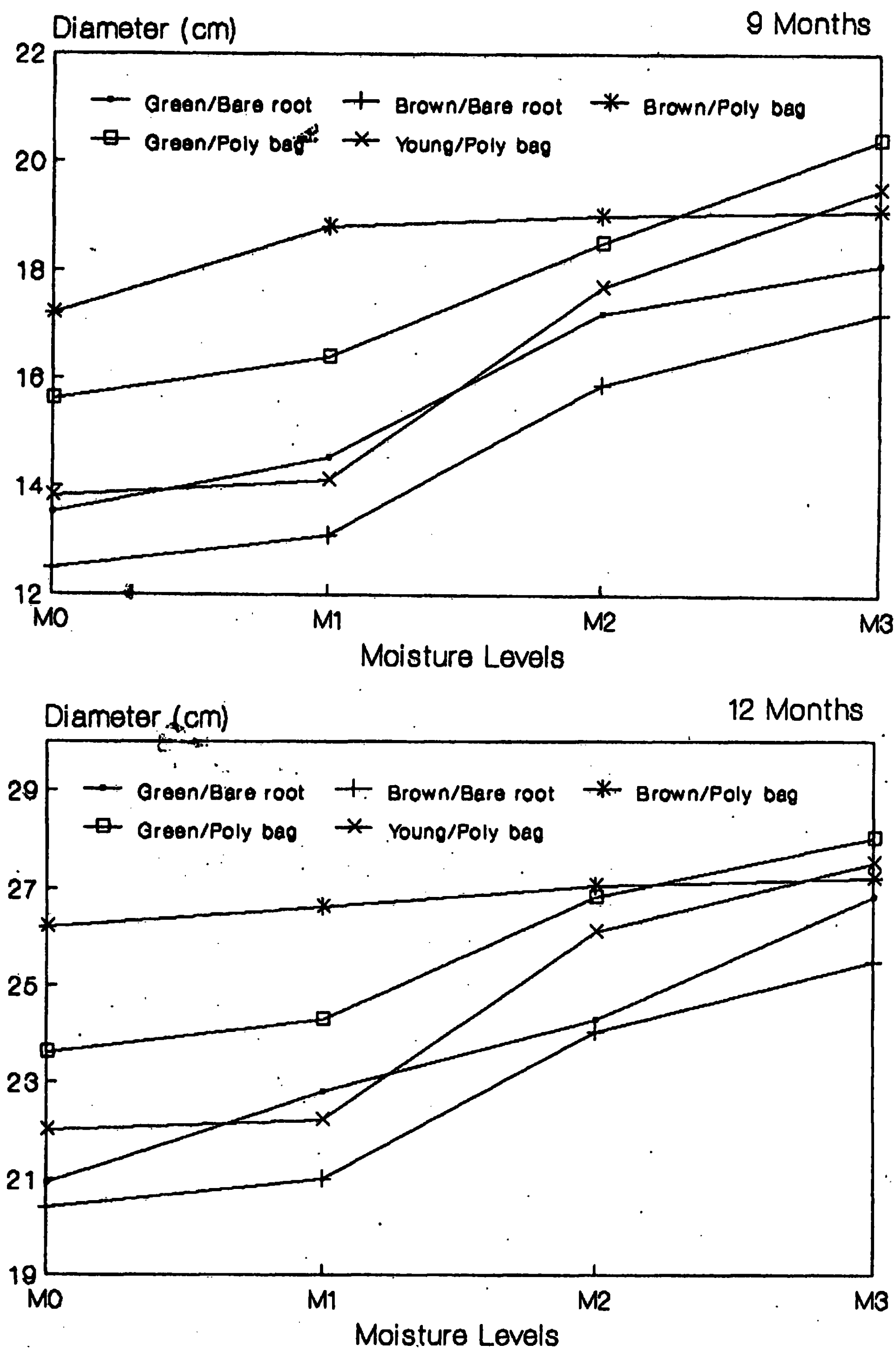

Fig. 1 Effect of establishment practices and moisture regimes on plant diameter.

Table 1. *Effect of establishment practices and moisture regimes on plant diameter.*

Treatment	Plant diameter (mm)	
	3 months	6 months
Brown budded polybags	13.08a	15.20a
Green budded polybags	10.16b	14.18b
Young budded polybags	9.75b	11.68c
Brown budded bare roots	7.00c	11.55c
Green budded bare roots	7.25c	10.02d
M0	9.13	10.45
M1	9.46	11.90
M2	9.53	13.36
M3	9.66	14.39
$LSD_{0.001}$	NS	0.61

A significant interaction ($P<0.001$) between establishment practices and soil moisture content on plant height was observed at the end of 12 months after planting (Fig. 2), where the pattern of response of different budded plants to different soil moisture levels was similar to that of plant diameter. A significant difference ($P<0.05$) between establishment practices on plant spread was observed, at the end of 12 months after planting where brown budded polybag plants were superior in spread compared to other establishment practices while spread was lowest in green budded bare roots (Table 2).

Table 2. *Effect of different establishment practices and moisture regimes on plant spread at the end of 12 months after planting*

Treatment	Plant spread (cm)
Brown budded polybags	98.08^{a}
Green budded polybags	92.58^{a}
Young budded polybags	95.75^{a}
Brown budded bare root	88.92^{ab}
Green budded bare root	82.83^{b}

The brown budded polybag plants had the highest number of whorls and highest leaf area compared to other establishment practices. It was also noted that with more moisture, number of whorls and leaf area increased significantly ($P<0.01$) in all the establishment practices (Table 3). Total dry weight accumulation data showed that there was a significant interaction ($P<0.001$) between different establishment practices and soil moisture regimes at the end of 12 months after planting (Fig. 3). At 10% and 30% available water levels, brown budded polybags showed higher total dry weights compared with other establishment practices. At higher levels of soil moisture, both brown and green budded polybag plants showed higher total dry weights compared with other establishment practices.

Table 3. *Effect of establishment practices and moisture regimes on number of whorls and leaf area at the end of 12 months after planting*

Treatment	Number of whorls	
Brown budded polybags	7.4^{a}	3.24^{a}
Green budded polybags	6.8^{a}	3.00^{a}
Young budded polybags	5.8^{b}	2.56^{b}
Brown budded bare roots	5.4^{bc}	2.45^{b}
Green budded bare roots	5.1^{c}	2.21^{b}
M_0	5.2	2.31
M_1	5.9	2.60
M_2	6.4	2.85
M_3	6.9	3.00
$LSD_{0.01}$	0.53	0.32

There was a significant difference ($P<0.001$) in root length, root spread and root dry weight between different establishment practices (Table 4) at the end of 12 months after planting.

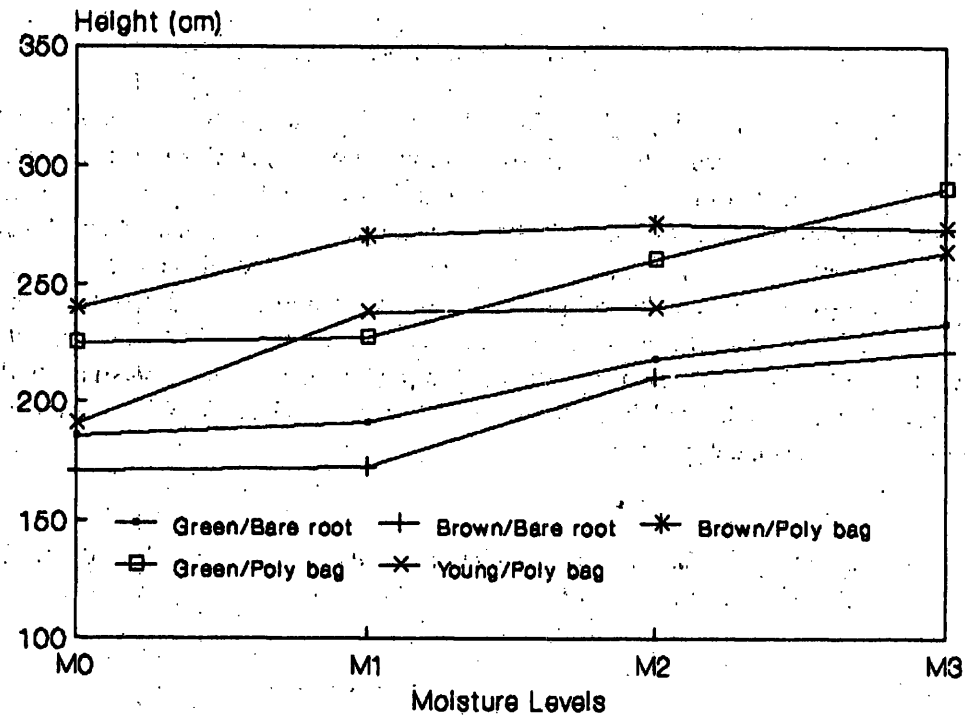

Fig.2 Effect of establishment practices and moisture regimes on plant height.

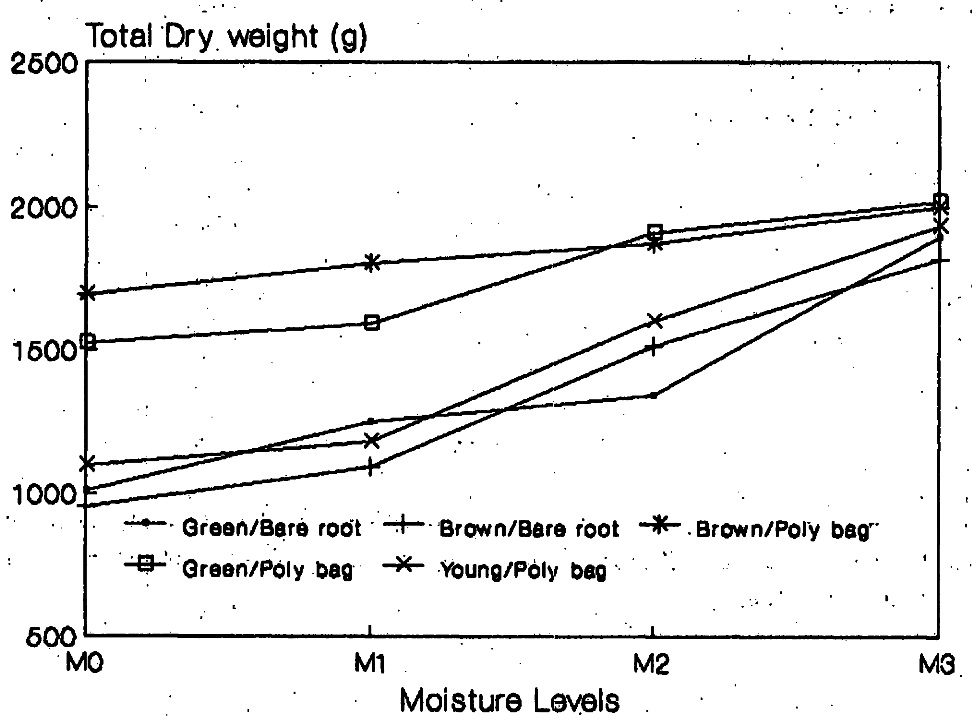

Fig. 3 Effect of establishment practices and moisture regimes on total dry weight.

Table 4. *Effect of different establishment practices on root length, root spread and root dry weight 12 months after planting*

Treatment	Root length (cm)	Root spread (cm)	Root dry weight (g)
Brown budded polybags	120.0[a]	50.0[a]	851.5[a]
Green budded polybags	109.9[b]	48.0[b]	752.3[b]
Young budded polybags	95.0[c]	43.1[c]	610.0[c]
Brown budded bare roots	83.1[d]	37.9[d]	458.0[d]
Green budded bare roots	80.0e	36.0[e]	404.7[e]

A significant interaction ($P<0.01$) was observed between establishment practices and soil moisture levels on leaf nitrogen and potassium contents (Fig. 4), where at low soil moisture levels, leaf nitrogen and potassium contents were greater in brown budded polybag plants. There was a significant difference ($P<0.01$) between establishment practices in leaf phosphorous (P) content irrespective of the soil moisture content. Brown budded polybag plants showed the highest leaf P content (Table 5).

Table 5. *Effect of establishment practices on leaf P content at the end of 12 months after planting*

Treatment	Leaf P (%)
Brown budded polybags	0.2666[a]
Green budded polybags	0.2211[b]
Young budded polybags	0.2079[b]
Brown budded bare roots	0.2050[b]
Green budded bare root	0.2003[b]

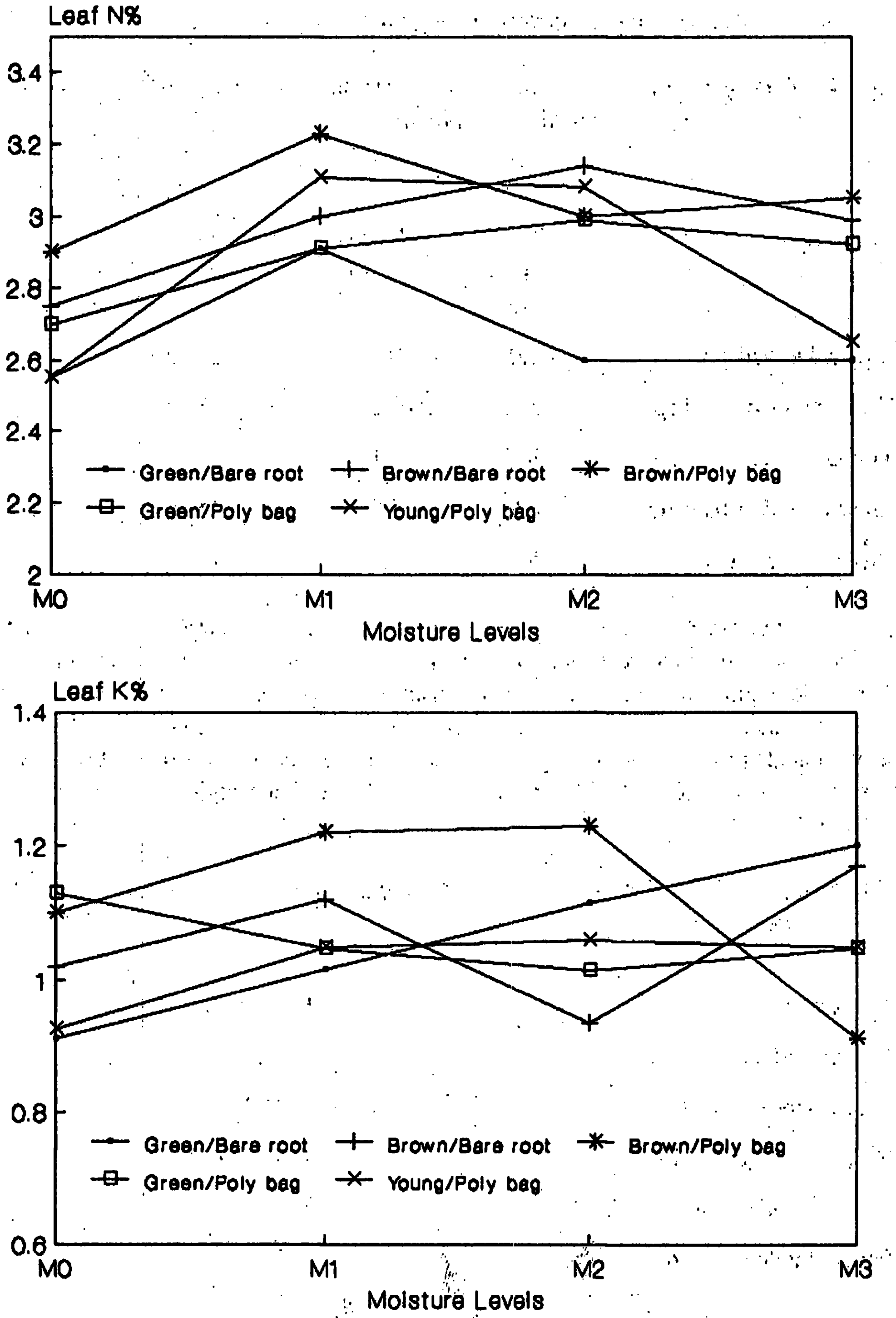

Fig. 4 Effect of establishment practices and moisture regimes on leaf N and K contents.

A significant difference ($P<0.001$) between establishment practices on micro-tapped yield of latex was observed, where brown budded polybag plants showed the highest value compared with other practices. It was also noted that with more soil moisture, latex yield increased significantly ($P<0.001$) (Table 6).

Table 6. *Effect of establishment practices and soil moisture regimes on micro-tapped latex yield.*

Treatment	**Yield (g/t/t)**
Brown budded polybags	74.50^{a}
Green budded polybags	66.48^{b}
Young budded polybags	52.96^{c}
Brown budded bare roots	49.74^{c}
Green budded bare roots	43.21^{d}
M_0	46.20
M_1	53.49
M_2	62.01
M_3	67.85
$LSD_{0.001}$	**3.68**

There were no differences in Leaf Water Potential (LWP), Relative Water Content (RWC), Transpiration Rate (TR) and Leaf Diffusive Resistance (LDR) between establishment practices. However, there was a significant difference ($P<0.001$) between different soil moisture levels on LWP,RWC, TR and LDR (Table 7).

Table 7. *Effect of soil moisture regimes on LWP,RWC,TR and LDR*

Treatment	LWP (-MPa)	RWC (%)	TR ($\mu g\ cm^{-1} sec^{-2}$)	LDR (Scm^{-1})
M_0	1.44	75.50	5.33	1.97
M_1	1.25	82.08	7.99	0.94
M_2	1.12	90.68	11.04	0.75
M_3	1.02	95.57	10.62	0.51
$LSD_{0.001}$	**0.20**	**6.10**	**3.01**	**0.57**

DISCUSSION

During recent years there have been few developments in the method of establishment of rubber plants in the field. But in general it was felt that adequate availability of soil moisture during field establishment is important for establishment success of plants raised under different establishment practices and therefore planting is normally done with the monsoonal rains.

In this study when the growth patterns at 3 and 6 months after planting, in response to different establishment practices and soil moisture levels were compared, it is clear that the growth of brown budded polybag plants was superior compared with other establishment practices such as green budding polybags, young budding polybags, brown budded bare roots and green budded bare roots. In general, plants raised in polythene bags appear to have an initial advantage over the use of bare root budded stumps. Moreover, the initial scion growth in brown budded bare roots was faster than that in green buddings. The green buds however sprouted earlier than the brown buds, with the result that the growth of both types of buddings at later stages remained similar. Even though the initial growth of brown budded polybags was superior to other establishment practices at higher soil moisture levels, the differences narrowed down by the end of 12 months after planting. These results seem to suggest that with an adequate amount of soil moisture the subsequent growth of all types of buddings after establishment may be practically the same.

It was also noted that the growth of brown budded polybags was superior to the other four establishment practices tested, even at the very low soil moisture level of 10% available water, and this difference was seen even at 12 months after planting. These results indicate that the brown budded ploybag plants would perform better under low soil moisture conditions. The plant height measurement further provides evidence of significantly better growth of brown budded polybag plants under stress conditions. As would be expected the significant differences in height, among different establishment practices at low soil moisture levels, narrowed down at higher levels of soil moisture, indicating that subsequent growth of plants after establishment in the field, would be same under all the planting techniques with adequate soil moisture. As evident from the data obtained, better growth resulted in higher total dry weight of brown budded polybags even under low soil moisture conditions. Thus, even under moisture stress conditions brown budded polybag plants showed greater vigour than other establishment practices. Plant spread, number of whorls, and leaf area are all estimates of plant vigour. These parameters also indicate that brown budded polybagged plants would perform better than the other establishment practices under low soil moisture conditions and would therefore enable rubber to be established successfully in areas where soil moisture can be limiting.

Data on the influence of soil moisture on root growth of differently budded plants indicates that brown budded polybag plants had significantly higher root growth compared to other establishment practices. It appears that root growth in relation to length and spread may have had greater effect in the performance of rubber plants in the first 12 months of its growth. Young plants are less likely to survive in soils with inadequate supply of moisture at the surface (Samarappuli, *et al*, 1993), this is particularly so during the dry periods. Brown budded polybag plants with more efficient root systems in relation to length and spread would enable the young plants to tap on a larger reservoir of moisture beneath the surface, thereby increasing the efficiency with which the plants would absorb soil water and nutrients. This may enhance better initial establishment and early growth of rubber plants under less favorable environment in relation to moisture. Moreover, the deeper penetration of roots is obviously advantageous in providing sufficient anchorage in the initial stages of establishment of the rubber plants in areas marginal with regard to moisture such as in Matale, Badulla *etc* where wind is also considered a problem.

Leaf analysis provides evidence of the uptake of N, P and K by differently budded plants in relation to soil moisture. The leaf P content was greater in brown budded polybag plants compared to other planting techniques irrespective of the level of soil moisture. As phosphate is not known to be mobile in the soil, it is not surprising that P uptake was not influenced by the level of soil moisture (Yogaratnam and De Mel, 1985). It was noted that the N and K uptake by brown budded polybag plants was superior to other practices tested even at the low soil moisture level of 30% available water, suggesting that low level of soil moisture is sufficient for brown budded polybag plants to extract nutrients in particular N and K. It is obvious that better root growth would enhance more efficient nutrient uptake, leading to improvement in the performance of rubber plants in terms of growth at the initial stages. On the other hand excessive moisture would have resulted in the leeching down of N, and K away from the root zone.

In this study, yield assessment by micro-tapping was used to compare the potential yield performance of the plants established with different planting techniques under different soil moisture levels. Similar to the results observed with some growth parameters discussed earlier, micro-tapped yield of brown budded polybag plants was superior to that of the other practices. Higher growth activities as suggested by the data on various growth parameters would have obviously resulted in increased latex production.

This study seems to suggest that in general, using polybag plants would prove to be more advantageous over bare root materials. The bare root budded stumps however, had shown higher girth increment during the subsequent years of growth, under adequate supply of moisture, thus reducing the initial differences in girth. It therefore follows that under best management conditions with adequate soil moisture, bare root budded stumps also could be used successfully. However, an important finding that emerges from this study is that, brown budded polybag plants would prove to be the best among the planting techniques that could be used in environments unfavorable in relation to soil moisture. The early efficient growth of such materials at the time of planting would even eventually help in tiding over the stress periods as well. Nevertheless, the disadvantages in using brown budded polybags for large scale planting are, the initial comparatively high cost of establishment and the difficulties involved in transporting of the relatively heavy bags. The latter disadvantage could be overcome to a certain extent by establishing the buddings in polythene bags close to the site of planting.

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