

PERFORMANCE OF SOME RRIC 100 SERIES CLONES UNDER DIFFERENT SOIL MOISTURE REGIMES

Lalani Samarappuli, N Yogaratnam and R Hettiarachchi

ABSTRACT

Results obtained on the performance of recently developed RRIC 100 series clones when subjected to water deficit situations are presented in this paper. The plant diameter of RRIC 121 and RRIC 102 was found to be superior to other clones tested such as RRIC 100, RRIC 110 and PB 86 even at the very low soil moisture level of 10% available water. Similar results were recorded in relation to plant height, number of whorls and leaf area. As would be expected better growth resulted in higher total dry weights and relative growth rates of clones RRIC 121 and 102 even under low soil moisture conditions. Data obtained also showed that clones RRIC 102 and 121 had the highest plant nitrogen and potassium contents. Moreover, even under very low soil moisture levels plant P content was greater in clones RRIC 121 and RRIC 102.

Most of the data on growth are also consistent with the physiological parameters such as Leaf Water Potential (LWP) Relative Water Content (RWC), Transpiration Rate (TR) and Leaf Diffusive Resistance (LDR). It was further noted that the LWP and RWC were highest while TR was lowest in clone RRIC 102. Moreover, the clone RRIC 102 had the highest LDR compared to other clones, confirming the ability of this clone in maintaining a higher water holding capacity under low soil moisture conditions.

INTRODUCTION

Soil and atmospheric moisture stress and high temperature are major environmental factors which limit growth and yield in *Hevea* in some rubber growing areas in Sri Lanka. Identification and breeding of clones tolerant to these stresses are important. Stress tolerant clones are of special importance for successful cultivation

PERFORMANCE OF CLONES UNDER DIFFERENT MOISTURE REGIMES

of *Hevea* in comparatively dry areas like, Kurunegala, Matale, Monaragala, Bibile etc. Early evaluation of stress resistant traits will be very useful in this context. Growth, yield and some physiological parameters such as stomatal conductance, photosynthesis rate and leaf water potential are important indices associated with moisture stress in *Hevea*.

Presently new clones are recommended for commercial planting only after monitoring the field performance of the clones for at least 20 years (Jayasekera, 1991). Studies on more fundamental characteristics like vigour of growth, some physiological parameters and yield by microtapping could be useful in understanding the performance of the rubber trees under moisture stress conditions. This paper presents results obtained on clonal variations pertaining to some plant physiological indices and their effects on growth and yield. These information could be useful in effecting crop improvement and in early selection of *Hevea* clones for cultivation in comparatively drier ecological regions in Sri Lanka.

MATERIALS AND METHODS

A pot experiment was started at Dartonfield estate, Agalawatta to study the effects of four levels of moisture on the performance of five different clones of *Hevea* plants. The plants were grown in empty barrels with both lids removed. 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 the 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 rain water coming in during the heavy rainy periods.

One whorled green budded polybag plants were planted and pre-treatment plant assessments were done. Four levels of moisture and five different *Hevea* clones were tested in a fully randomized design with single tree plots replicated four times.

The 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

The five different clones are:

C ₁	-	PB 86
C ₂	-	RRIC 100
C ₃	-	RRIC 102
C ₄	-	RRIC 110
C ₅	-	RRIC 121

N,P,K and Mg fertilizers were added uniformly according to the RRISL recommendations. Growth assessments, plant nutrient contents, physiological parameters and micro tapped yield were recorded periodically.

RESULTS

There were significant differences ($P<0.001$) between different clones on plant diameter, height, spread, number of whorls and leaf area, made at the end of 12 months after commencement of the experiment. Data obtained also showed that with more moisture, plant diameter, height, spread, number of whorls and leaf area increased significantly ($P<0.001$), irrespective of the clone (Table 1).

Table 1. *Effect of different clones and moisture regimes on plant diameter, height, spread, number of whorls and leaf area*

Treatment	Plant diameter (mm)	Plant height (cm)	Plant spread(cm)	No. of whorls	Leaf area (m ²)
RRIC 102	20.00 ^a	269.8 ^{ab}	109.0 ^a	6.25 ^a	2.39 ^a
RRIC 121	18.86 ^{ab}	291.1 ^a	101.0 ^b	6.13 ^{ab}	1.90 ^b
RRIC 110	17.13 ^{bc}	243.5 ^{bc}	104.8 ^{ab}	5.69 ^{ab}	1.59 ^c
RRIC 100	16.00 ^{cd}	226.0 ^c	108.5 ^a	5.44 ^b	1.47 ^c
PB 86	14.81 ^d	169.8 ^d	101.6 ^b	4.19 ^a	1.44 ^c
M ₃	20.30	280.8	116.8	6.10	2.21
M ₂	17.50	254.8	111.6	5.85	1.84
M ₁	16.65	231.6	99.7	5.55	1.60
M ₀	15.00	185.0	93.4	4.65	1.39
LSD	1.92	27.0	5.1	0.588	0.19

Total dry weight accumulation data showed that there was a significant interaction ($P<0.001$) between different clones and soil moisture regimes (Fig. 1). At

PERFORMANCE OF CLONES UNDER DIFFERENT MOISTURE REGIMES

30% available water level, clones RRIC 121 and RRIC 102 showed higher total dry weights compared to other three clones. At 70% available water level, clones RRIC 121, RRIC 102 and RRIC 100 showed higher total dry weights compared to other clones. Relative Growth Rate Data (RGR) also showed that there was a significant interaction ($P < 0.001$) between different clones and soil moisture regimes. The pattern of response was similar to that of total dry weight (Fig. 2).

Root data obtained showed that there was no significant difference between clones. However, there were significant differences ($P < 0.001$) between different soil moisture levels on root length, spread and dry weight (Table 2).

Table 2. *Effect of different soil moisture regimes on root length, root spread and root dry weight.*

Treatment	Root length (cm)	Root Spread (cm)	Root dry weight (g)
M ₃	115.5	44.8	824.0
M ₂	117.4	46.1	624.9
M ₁	110.5	44.6	461.2
M ₀	97.3	42.3	398.2
LSD	2.3	1.8	43.2

There was a significant difference ($P < 0.05$) between clones on bark nitrogen and leaf potassium contents irrespective of the soil moisture level (Table 3). A significant interaction ($P < 0.05$) between clones and soil moisture levels on leaf P content was observed (Fig. 3), where at low soil moisture level, P content was greater in clones RRIC 121 and 102.

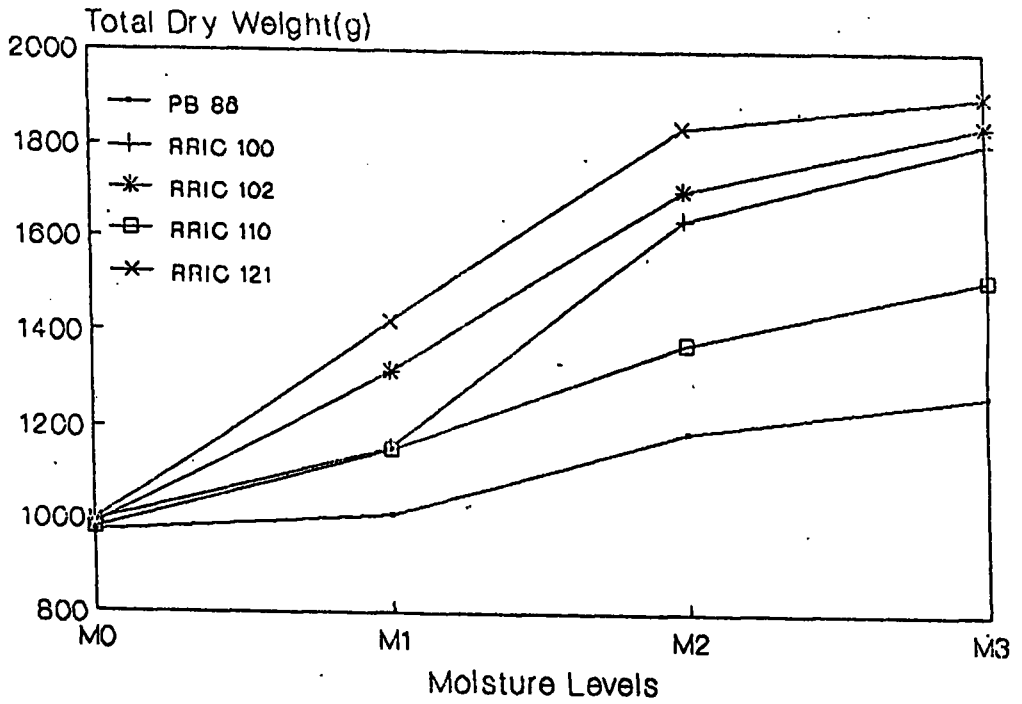


Fig. 1 Effect of different clones and moisture regimes on total dry weight

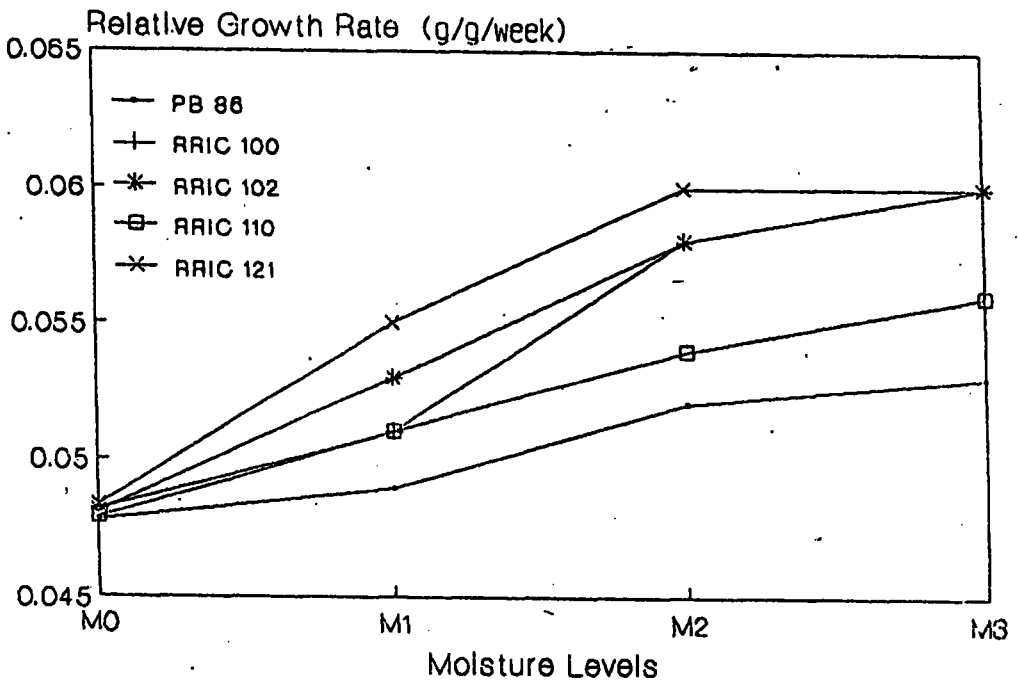


Fig. 2 Effect of different clones and moisture regimes on relative growth rate

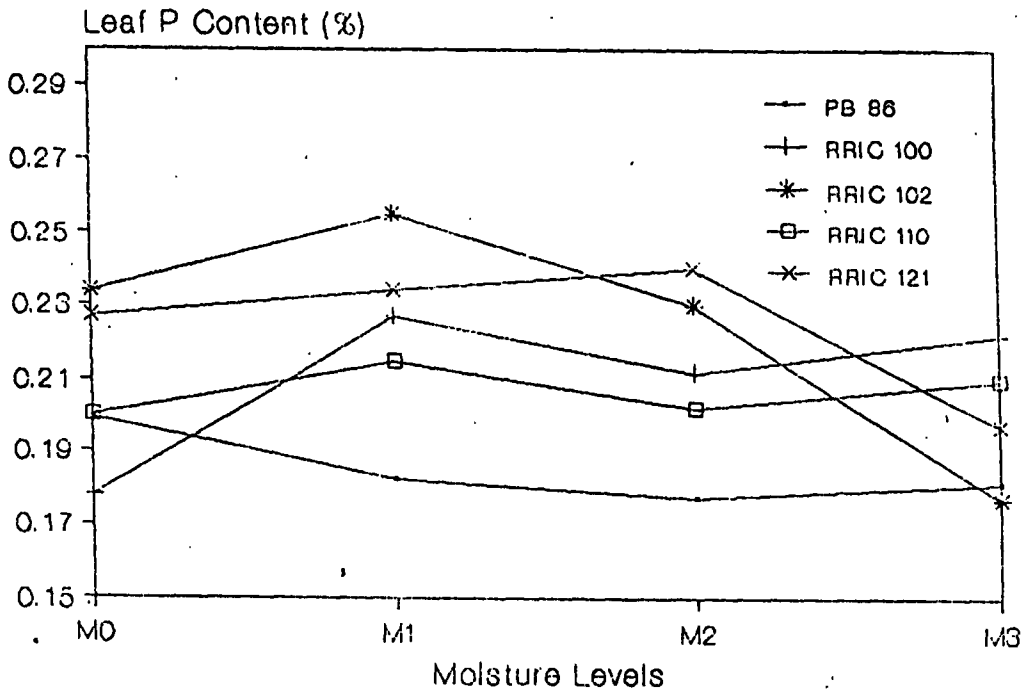


Fig. 3 Effect of different clones and moisture regimes on leaf P content

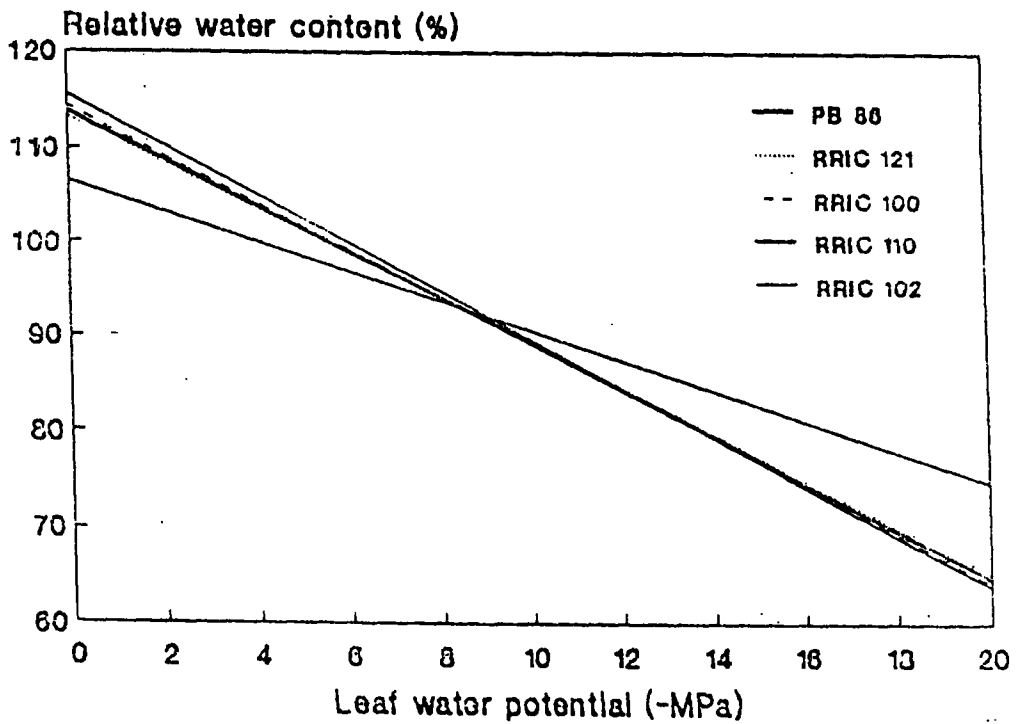
Table 3. *Effect of different clones on bark N and leaf K contents*

Treatment	Bark N content (%)	Leaf K content (%)
RRIC 121	0.9263 ^a	1.0375 ^a
RRIC 102	0.8831 ^{ab}	1.0306 ^a
RRIC 100	0.8544 ^{ab}	0.9782 ^{ab}
RRIC 110	0.8394 ^{ab}	0.9269 ^{ab}
PB 86	0.7875 ^b	0.8367 ^b

Assessments of Leaf Water Potential (LWP), Relative Water Content (RWC) and Transpiration Rate (TR) showed a significant difference ($P < 0.05$) between clones. Irrespective of the clone, there was a significant increase ($P < 0.001$) in LWP, RWC and TR with the increase in the level of soil moisture (Table 4). Relationship between RWC and LWP of different clones is given in Fig. 4.

Table 4. *Effect of different clones and moisture regimes on LWP, RWC and TR*

Treatment	LWP (-MPa)	RWC (%)	TR ($\mu\text{gcm}^{-2} \text{sec}^{-1}$)
RRIC 102	0.98 ^a	90.19 ^a	10.035 ^a
RRIC 121	1.08 ^{bc}	87.91 ^{ab}	11.466 ^b
RRIC 100	1.05 ^{ab}	87.26 ^{ab}	10.684 ^{ab}
PB 86	1.12 ^{bc}	86.44 ^b	11.483 ^b
RRIC 110	1.15 ^c	84.90 ^b	11.299 ^b
M ₃	0.80	97.61	7.869
M ₂	0.95	91.39	9.011
M ₁	1.14	82.58	11.222
M ₀	1.42	77.76	15.872
LSD	0.83	0.78	0.776



Clone	Relationship
RRIC 102	$Y = 107.80 - 1.52 X$ ($r=0.85$)
PB 86	$Y = 113.85 - 2.45 X$ ($r=0.81$)
RRIC 121	$Y = 113.30 - 2.39 X$ ($r=0.72$)
RRIC 100	$Y = 114.34 - 2.50 X$ ($r=0.78$)
RRIC 110	$Y = 115.56 - 2.58 X$ ($r=0.77$)

Fig. 4 Relationship between relative water content and leaf water potential of different clones

Leaf Diffusive Resistance (LDR) showed a significant interaction ($P < 0.05$) between different clones and soil moisture regimes (Fig.5). At low soil moisture regimes *i.e.* 10% and 30% available water levels, clone RRIC 102 showed the highest LDR compared to other clones.

Micro tapped yield also showed a significant interaction ($P < 0.01$) between different clones and soil moisture regimes (Fig.6). At 30% available water level, clones RRIC 121 and RRIC 102 showed higher yields. Yield was maximum in clone RRIC 121 at 50% available water level.

DISCUSSION

Soil moisture stress is one of the major environmental factor which limits growth and yield of *Hevea* in some rubber growing areas in Sri Lanka. Breeding and identification of clones tolerant to moisture stress is therefore important. Stress tolerant clones are of special importance for successful cultivation of *Hevea* in comparatively dry areas like Kurunegala, Matale, Monaragala, Bibile etc. Identification of stress resistant clones at the early stages of Breeding and selection programme is considered very useful in this regard.

This study has shown that the plant diameter of RRIC 121 and RRIC 102 were superior to other clones tested even at the very low soil moisture level of 10% available water. Nevertheless, it appears that in general all RRIC 100 series clones are superior in growth to clone PB 86 with regard to their performance under stress conditions. Similar results were recorded in relation to plant height, leaf area and number of whorls, although the canopy spread was significantly high in clone RRIC 102. These variations in growth are probably due to inherent clonal characteristics (Nugawela and Aluthewage, 1986). In areas marginal with regard to moisture such as Matale, Bibile and Moneragala, where perennial grasses like illuk are considered a problem, clone RRIC 102 with a denser canopy may be effective in atleast partially keeping these grasses under control.

As would be expected, better growth resulted in higher total dry weights of clones RRIC 121 and 102 even under low soil moisture conditions. Thus, even under moisture stress conditions clones RRIC 121 and 102 showed greater vigour than the other clones. The increase in vigour shown by these 2 clones at the early stages (12 months) would enable, if this trend is continued in the next 3 to 4 years, for rubber to be grown in the marginal areas like Matale, Bibile etc. The Relative Growth Rate (RGR) determined after 12 months of growth of clones RRIC 100, RRIC 102, RRIC 110, RRIC 121 and PB 86 in relation to different soil moisture levels were significantly different. The highest values were recorded by RRIC 121 and 102 even under low moisture conditions. This shows that there had been an increase in net dry matter production during the 12 month period. These indices all indicate that the clones RRIC 121 and 102 would perform better under low moisture conditions.

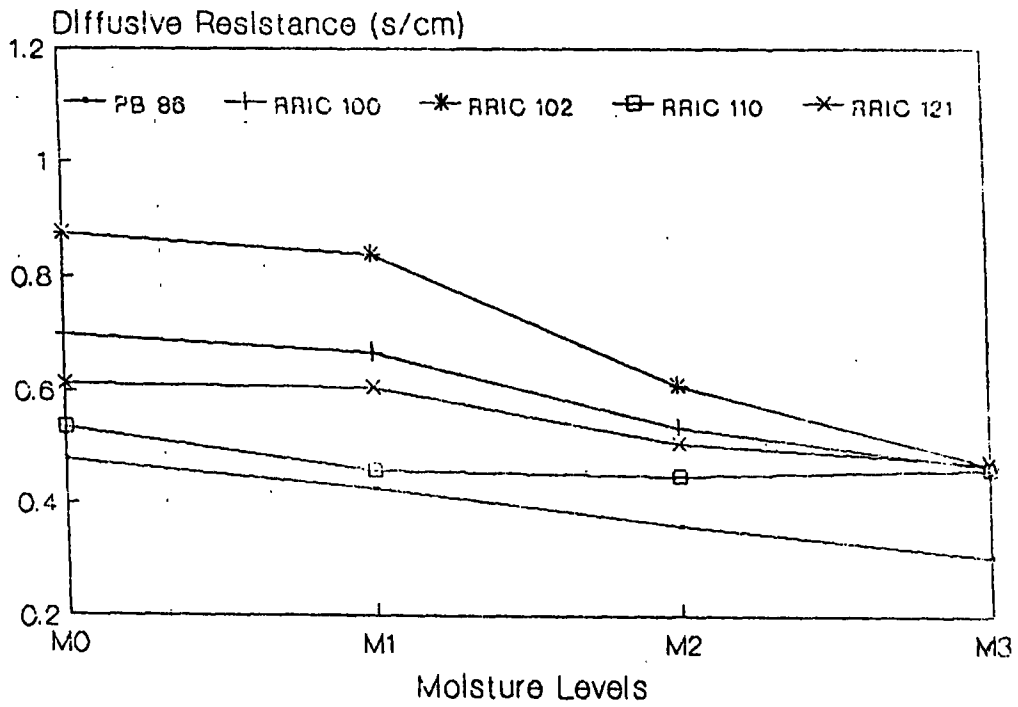


Fig. 5 Effect of different clones and moisture regimes on diffusive resistance

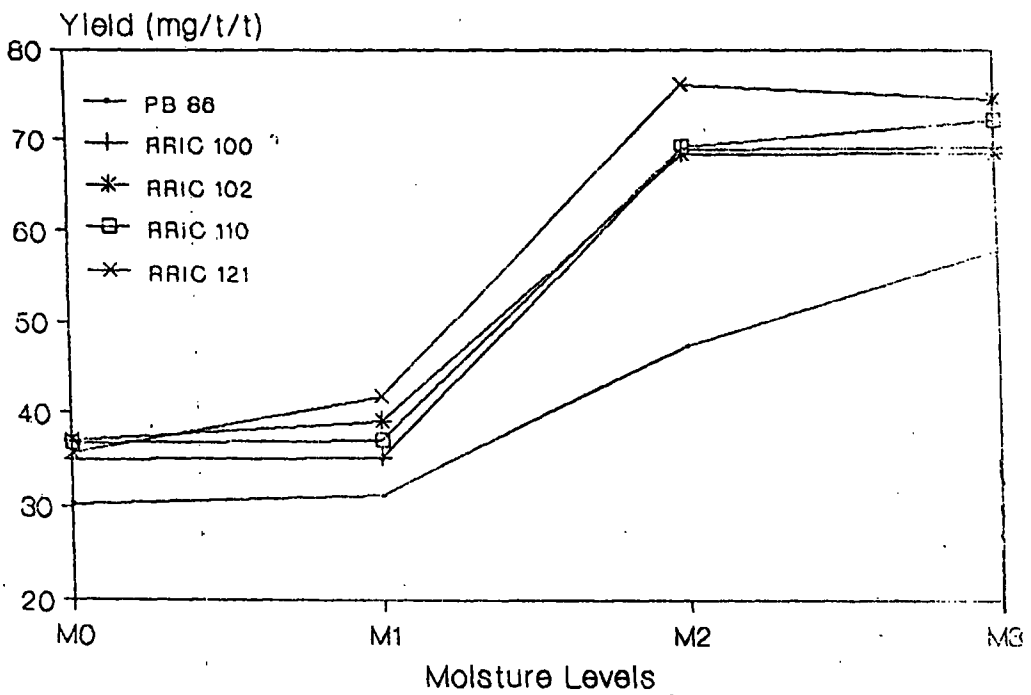


Fig. 6 Effect of different clones and moisture regimes on yield

It was further noted that the soil water deficit caused a reduction in root growth and thereby decreasing the efficiency with which the plants would absorb soil water and nutrients. Clemens and Jones (1978) reported that drought caused no change in plant performance but caused a significant reduction in root dry weight. Decreased root growth under moisture stress may be related to the hormonal imbalance created by moisture stress. As there was no significant difference in root growth among clones, it appears that root growth in relation to length and thickness may not have had any effect on the performance of rubber plants in the first 12 months of its growth.

The leaf and bark analysis provide evidence of the uptake of N, P and K by the clones tested in different manner. It was noted that, irrespective of the levels of soil moisture, in general clones RRIC 102 and 121 exhibited a greater uptake of nitrogen and potassium. Moreover, even under very low soil moisture levels P uptake was greater in clones RRIC 102 and RRIC 121 suggesting that very low level of soil moisture is sufficient for these 2 clones to extract nutrients in particular N, K and P. As phosphate is not known to be mobile in the soil it is not surprising that for P uptake high level of soil moisture was not required by clones 102 and 121 (Yogaratnam and De Mel, 1985). It is however difficult to explain the pattern of P uptake by clone RRIC 102 and 121 where with increase in soil moisture, P uptake decreased.

It is known that latex yields recorded in dry areas specially during drought periods are generally low (Fernando, 1977). In this study, yield assessment by microtapping was used to compare the yield performance of different clones under moisture stress conditions. Similar to the results observed with some growth parameters discussed earlier, micro tapped yields of clones RRIC 121 and 102 were superior to that of the other clones under water stressed conditions. Increased latex production under moisture stress may be related to various physiological parameters.

Various physiological indices have been used in this study to differentiate clonal response to soil moisture stress. It was shown that most of growth data are consistent with physiological parameters made. The results of leaf water potential (LWP), Relative Water Content (RWC) and Transpiration Rate (TR) for all the five *Hevea* clones subjected to water stress indicated that all these parameters decreased with the increasing levels of moisture stress in all the five clones. It was further noted that the LWP was highest in clone RRIC 102 and lowest in clone RRIC 110 indicating a higher water holding capacity in clone RRIC 102 as indicated by the values of relative water content and transpiration data. Moreover, relative water content (RWC) was significantly higher in the clone RRIC 102 confirming again the ability of this clone in maintaining a higher water holding capacity.

It appears in general that the water status of the clone RRIC 102 is better compared to other clones tested which also would enhance growth of the plants. The performance of young RRIC 102 plants may have been improved as a result of the

PERFORMANCE OF CLONES UNDER DIFFERENT MOISTURE REGIMES

better plant water status. It has also been reported earlier that cultivars believed to be more drought resistant usually maintained higher relative water content as well as higher leaf water potential (Hanson *et.al.* 1977; Carter and Patterson, 1985; Cortes and Sinclair, 1986; Schonfeld *et.al.* 1989). On the other hand the transpiration rate was also lowest in clone RRIC 102 compared to other clones. Moreover, leaf diffusive resistance data indicated that clone RRIC 102 had the highest leaf diffusive resistance which could result in a comparatively higher water use efficiency value (Kozlowski,1975).

Important finding that emerge from this study is that, physiological differences exist among clones when grown under low soil moisture conditions. Since most of the variation in gas exchange in plants under low soil moisture conditions is due to leaf diffusive resistance, it seems to suggest that leaf diffusive resistance may serve as a parameter for selecting clones for marginal rubber growing areas. Moreover, it seems possible that clone RRIC 102 might perform better compared to other clones *i.e.* RRIC 100, RRIC 110, RRIC 121 and PB 86, under low soil moisture conditons.

ACKNOWLEDGEMENT

The authors wish to thank Mrs Wasana Wijesuriya Assistant Biometrician for her valuable assistance in statistical analysis. The help given by the technical staff of the Soils and Plant Nutrition Department is also gratefully acknowledged.

REFERENCES

- Carter, J E Jr and Patterson, R P (1985). Use of relative water content as a selection tool for drought tolerance in soybean. In *Agronomy abstract, ASA, Madison, Wisconsin*, 77.
- Clemens, J and Jones, P G (1978). Modifications of drought resistance by water stress conditioning in Acacia and Eucalyptus. *J. Exp. Bot.*, 29 : 895 - 904.
- Cortes, P M and Sinclair, T R (1986). Water relations of field grown soybean under drought. *Crop Sci.*, 26: 993 - 998.

- Fernando, D M (1977). Recent developments in rubber planting material. *Bull. Rubb. Res. Inst. Sri Lanka*, 12 (1) : 33 - 40.
- Hanson, A D; Nelsen, C E and Everson, E H (1977). Evaluation of free proline accumulation as an index of drought resistance using two contrasting barley cultivars. *Crop Sci.*, 17 : 720 - 726.
- Jayasekera, N E M (1991). Personal communication.
- Kozlowski, T T (1975). Water relation and tree improvement. *In Tree physiology and yield improvement.* eds. M G R Cannel and F T Last, Academic Press, London, 27 - 43.
- Nugawela, A and Aluthhewage, R K (1986). Clonal differences in growth parameters of young *Hevea* buddings and their relation to field performance. *J. Rubb. Res. Inst. Sri Lanka*, 66 : 30 -36.
- Schonfeld, M H; Johnson, R D; Carver, B F and Mornhinweg, D W (1988). Water relation in winter wheat as drought resistance indicators. *Crop Sci.*, 28 : 526 - 531.
- Silva, C G (1964). Provisional classification of rubber soils of Ceylon and their relationship to Malayan soils. *J. Rubb. Res.Inst. Malaya*, 24 : 217 - 224.
- Yogarathnam, N and De Mel, J G (1985). Effect of fertilizers on leaf composition of NPK in some *Hevea* cultivars. *J. Rubb. Res. Inst. Sri Lanka*, 63 : 17 - 25.