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Study on Yield and Yield Components of *Hevea* Clones During Water Stress in 1987

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Summary

Semi-diurnal changes in the components of plant water relations and meteorological variables were recorded during drought in 1987. Soil water potentials were well below the wilting point upto 90 cm depth. Results indicate significant variations in yield and yield components between these two clones. RRII 105 had higher rubber yields than RRII 118. These two clones differ significantly in their afternoon leaf water potentials, latex vessel turgor, stomatal resistance, transpiration, xylem sap speeds, and relative transpiration ratios. RRII 105 was found to maintain lower transpiration rates, higher xylem sap speeds and water potentials. Better turgor maintenance was also noticed in RRII 105, which results in higher latex yields. Clonal variations in yield and yield components are discussed in relation to components of plant water relations and atmospheric factors.

Introduction

Natural rubber is obtained by processing the latex of *Hevea brasiliensis* by tapping. The latex flows out from a tapping cut mainly because of high turgor pressure (1.0 - 1.5 MPa) in the latex vessels (Buttery & Boatman, 1976). Initially the flow rate is high after tapping which declines later due to reduction in turgor pressure as well as initiation of plug formation at the cut ends of the latex vessels. Normally the flow stops after 2-3 hr. Though latex flow characteristics have been studied under the influence of soil moisture stress (Sethuraj & George, 1976), no systematic approach has been made to relate the changes in flow characteristics with components of soil-plant and atmosphere system. The present paper reports the observations made during the dry season on soil-*Hevea*-atmosphere system in relation to yield variations in Rubber.

Materials and Methods

Trees (10 yr old) of clones RRII 105 (drought resistant) and RRII 118 (drought susceptible) were planted at a distance of 4.9 x 4.9 m. at the Rubber Research Institute of India Central Experiment Station, Chethackal (9° 22' North, 76° 50' East) in oxisol type soil. Observations were made during the moisture stress period of 1987 (April, 1987) with 5 replications. Both the clones were under 1/2 S d/2 system of tapping.

Observations on semi-diurnal changes in components of soil-plant-atmosphere system were made in both the clones. Leaf water potentials (ψleaf) and latex solute potentials (Latex $\psi\pi$) were measured using C-52 sample chamber psychrometer (Wescor Inc., Logan, Utah, USA). Stomatal resistance and transpiration rates were measured using LI-1600 Steady state porometer (LICOR Instruments, USA).

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Xylem sap speeds (xss) were monitored using Model HP1 Sap Flow Meter which works on heat pulse technique (Hayashi Denkoh, Japan). Latex vessel turgor was monitored using disposable manometers developed by Raghavendra *et al.* (1984). Yield (g $tree^{-1}$ min^{-1}) and yield components like initial flow rate (ml $cm^{-1}min^{-1}$), rubber content (%, V/W) and plugging index were recorded. Plugging index was determined according to Milford et al. (1969).

$$\text{Plugging index} = \frac{\text{Mean flow rate (ml/min) during the first 5 min. after tapping}}{\text{Total yield volume (ml)}} \times 100$$

The daily transpiration was obtained by integrating the hourly observations for the day time and by taking the mean values of predawn and dusk transpiration rates as the mean of night transpiration. The sap flow rate for 12 hr was worked out by taking the cumulative values of hourly recordings.

Vapour pressure deficits were calculated from the measurements on wet and dry bulb temperatures made in the open area adjacent to the experimental site that represents that of the bulk air. Irradiance was measured using LI-1800 Spectroradiometer (LICOR Instruments, USA).

Results

Soil Water Potential

The soil water potentials were -0.203 MPa at 0-30 cm depth and less than wilting point at 30-90 cm depth (-1.5 MPa, Table 1). The higher water potential in the surface layer is due to the two showers (16 to 32 mm) received prior to the observations.

Environmental and Plant Factors — Semi-diurnal changes in environment [ambient temperature (T), vapour pressure deficit (VPD) and irradiance (Ir, 300-1100 nm)] and components of plant water relations (leaf water potential, stomatal resistance, transpiration, xylem sap speed, latex vessel turgor and latex solute potentials) are depicted in Fig. 1a & b for clones RRII 105 and RRII 118, respectively. Data on yield and yield components, and on selected physiological parameters are given in Table 2. Results indicate significant variations in yield and yield components between RRII 105 and RRII 118. RRII 105 had higher rubber yields $tree^{-1}$ tap^{-1} as compared to RRII 118. Among the yield components, initial flow rate was higher in RRII 105, while RRII 118 showed high plugging index and rubber content.

Among the other physiological parameters, afternoon leaf water potentials, latex vessel turgor, stomatal resistance and cumulative xylem sap speeds were found to be high in RRII 105. On the other hand, RRII 118 showed higher transpiration coefficient and transpiration rates.

Discussion

During the drought survey (March 1987), any live feeder roots were not found upto 0-30 cm depth. Though there were light rain the soil moisture below 30 cm depth was below the wilting point indicating incomplete recharging of the soil water status. Regeneration of feeder roots was not noticed during this period. Afternoon leaf water potentials observed during the

Table 1. Soil moisture content (%) and soil water potential (-MPa) in *Hevea* plantations (Clones RRII 105 and RRII 118) during the drought period in 1987

Soil depth	Soil moisture content (%)	Soil water potential
0-15 cm	12.46	- 1.50
15-30 cm	14.42	- 1.50
30-60 cm	16.18	- 1.60
60-90 cm	16.44	- 1.32

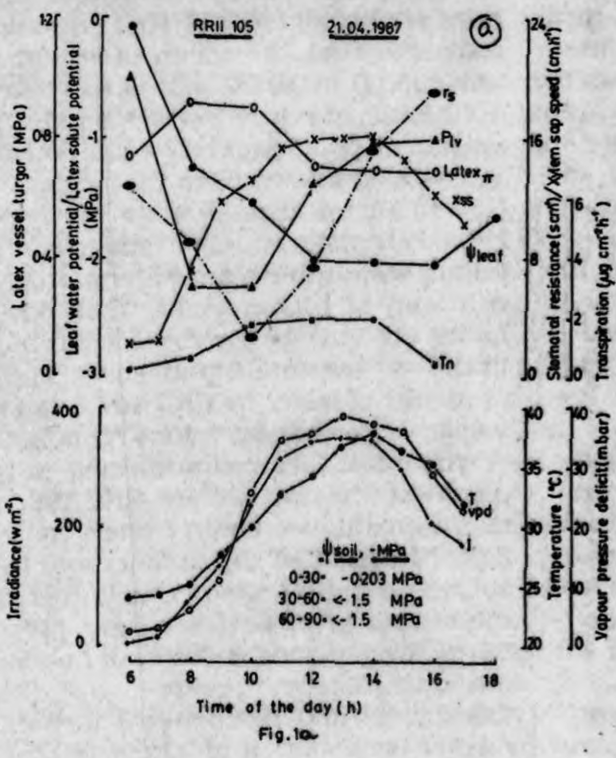

Fig. 1a

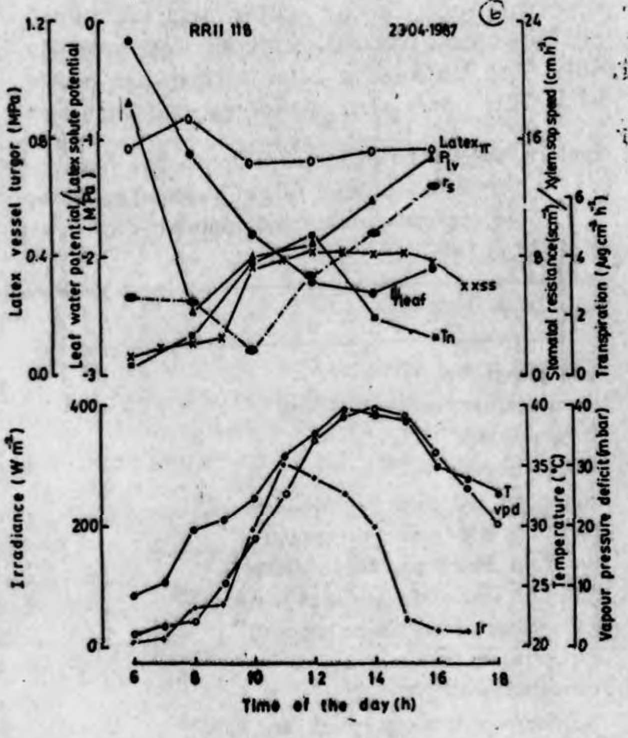

Fig. 1a & b. Semi-diurnal changes in components of plant water relations and meteorological variables in (a) clone RRII 105 and (b) clone RRII 118 observed during moisture stress period of 1987.

drought survey were comparable to the ones reported in the present study, thus indicating that at the time of present observations there was no relieving of stress by the scanty rains received . It have also been found that there were marked changes in leaf water potentials, xylem sap flow and transpiration etc. afterwards in the wet season (Unpublished).

From the data it can be seen that the turgor loss within the drainage area is mainly associated with the cutting open of the latex vessel ends. The continued loss of turgor is associated with the continued loss of latex from the drainage area. However, it is seen that clone RRII 105 maintains a high turgor inspite of the higher material loss. This is due to higher water potentials of the surrounding xylem tissue during the morning hours. The higher initial flow rate in RRII 105 is associated with significantly higher pre-dawn turgor pressures of the latex vessels.

From the present study it is also known that, though most of the nutrient and water uptake takes place in the surface layers during the wet season, during dry season much of the water and nutrients are absorbed from the deeper layers of the soil. The data also shows that the clone RRII 118 uses more water as compared to RRII 105, even though the xylem sap flow rates are higher for RRII 105. Present study indicates that the mean stomatal resistance (8.00 to 16.00 hrs) is more for RRII 105. RRII 118 had lower stomatal resistance inspite of lower leaf water potentials.

It is also known from the present study that in *Hevea* clonal variation in stomatal behaviour plays an important role in maintaining favourable plant water status which will lead to higher yield. This has been found not only in the dry season but also in the wet season (Unpublished). The higher uptake of water by RRII 105 was evident inspite of lower ψleaf values. This is another important factor contributing to higher plant water status in clone RRII 105, which results in higher flow of latex caused by higher turgor. The clonal difference in latex solute potentials also contributes to the maintenance of better turgor pressure. Since the plugging index is influenced by not only turgor pressure, but also by anatomical and biochemical factors. The relative contribution of these factors have to be separately quantified.

The relative transpiration ratio which now we call as "transpiration coefficient" is significantly different for the two clones (Table 2). This value has been found to change from around 1.0 in the wet season

Table 2. Yield, yield components (initial flow rate, plugging index, rubber content), after-noon leaf water potentials, latex vessel turgor, stomatal resistance, transpiration, relative ratios of transpiration/potential evapotranspiration and cumulative xylem sap speeds in RRII 105 and RRII 118 during the dry season of 1987

Parameter	RRII 105	RRII 118	C.D. 0.05
Yield (g tree $^{-1}$tap^{-1})**	46.26	18.62	5.22
Initial flow rate (ml cm^{-1} min^{-1})**	0.106	0.081	0.009
Plugging index**	3.95	5.59	0.292
Rubber content (%)**	44.2	45.6	0.744
After-noon leaf water potential (-MPa)**	1.88	2.42	0.265
Maximum latex vessel turgor (MPa)**	1.10	0.88	0.126
Minimum latex vessel turgor (MPa)**	0.30	0.17	0.038
Minimum stomatal resistance (s cm^{-1})NS	2.16	1.82	-
Mean stomatal resistance (s cm $^{-1}$)**	14.62	6.82	0.92
Transpiration (mm m $^{-1}$ day $^{-1}$)**	0.597	1.08	0.091
Transpiration/PET**	0.110	0.242	0.026
Cumulative xylem sap speed (cm/12 h)**	135.97	106.84	3.57

** Significant at 1% error.

(unpublished) to 0.2 in the dry season. The transpiration coefficient can be used as a tool for studying water requirement of tree crops where lysimeter recording are not feasible. Even though stomatal resistance was minimum in the fore-noon, transpiration rates were maximum in the after-noon, when the vapour pressure deficits were high.

The present study also demonstrates that studying the mean stomatal resistances and the integrated transpiration rates will provide a better quantification of the water relations of crop plants. Further studies in this direction are in progress.

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