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EVALUATION OF *HEVEA BRASILIENSIS* CLONES FOR YIELDING TRENDS IN TRIPURA

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A comparison of two yielding regimes of *Hevea brasiliensis* (Regime I – April to September – non-cold season and Regime II – October to January – cold season) with respect to 15 clones of varying yield potential evaluated in Tripura, indicated a congenial environment for yield in the cold season. The clones PB 235, RRII 118, RRII 203, RRIM 600 and RRIM 703 were ranked as high yielders considering the data from BO1 and BO2 panels. Among these, RRII 203 and PB 235 exhibited least depression in yield (18.6 and 31.9% respectively) during Regime I. In general, dry rubber yield showed negative relationship with minimum temperature, wind velocity and evaporation. However, PB 235 lacked any such relationship when considered individually, indicating thereby that it is less sensitive to yield stimulation towards the onset of cold season. The mean dry rubber yields (g/tree/tap) of PB 235 and RRIM 600 were regressed against environmental mean under the two regimes. Accordingly, 28 g/ tree/tap) was identified as the threshold yield under stress. In terms of yield per cm of tapping cut, PB 235, RRIM 703, RRII 203 and RRII 118 were found to be potential yielders. Covariance analysis categorised RRII 5, RRIM 703, PB 5/51 and PB 235 to be consistent over the regimes. Considering the attributes mean yield, per cent depression during Regime I, yield per unit length of tapping cut and consistency in yield over regimes, clones selected for commercial evaluation are PB 235, RRII 203, RRII 118 and RRIM 703 with RRIM 600 as check.

Key words : Consistency, Non-traditional environment, Stress factors, Yield depression, Yield regimes.

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INTRODUCTION

Macro-environmental attributes like temperature, rainfall, wind velocity, vapour pressure, sunshine hours, evaporation, relative humidity, soil moisture, soil fertility and pH, which are largely non-static but predictable, influence adaptation of genotypes. Predictable and non-predictable environments determine the phenotypic changes in a given genotype. While the different climatic and edaphic factors constitute the predictable (macro) environment, the changes in developmental pathways contribute largely to the unpredictable (micro) environment (Wu, 1997). In rubber, micro-environment can be considered as largely static but for the effect due to stock-scion interactions. Clones which are believed to be static and faithful replicates, when tested under non-static but different predictable environments, might express their genetic differences through phenotypic plasticity. Such specific adaptation is prevalent in plant species (Schlichting, 1986).

Under the climatic conditions in Tripura, *Hevea brasiliensis* presents two distinct yielding regimes (Priyadarshan *et al.*, 1998b) consisting of a lean period (April to September; Regime I) and peak period (October to January; Regime II). The performance of *Hevea brasiliensis* clones with regard to yielding trends and macro-environmental attributes gain prominence especially when almost equal returns from the stand over the months is to be ensured. The region between 10° north and south is believed to be ideal for rubber cultivation and any shift in this range obviously reflects changes in the macro-environment. Tripura (22° 56′ – 24° 32′ N and 91° 10′ – 92° 21′ E) offers a non-traditional environment for rubber cultivation. It has a sub-tropical humid climate experiencing a low temperature spell beginning with a cool period (October-November), which stimulates the dry rubber yield and total volume of latex (Priyadarshan *et al.*, 1998b). Thereafter, a recession in yield follows consequent to further decline in temperature towards the end of December to January. The preceding months (May to September) form a low yielding regime due to changes in the attributes of macro-environment.

Observations on adaptation of clones are more prudent in unfavourable environment wherein greater selection pressure helps to identify less adapted genotypes. Under the climatic conditions of Tripura, Regime I shall be considered unfavourable. This paper highlights the yielding trends of 15 clones with special emphasis on the macro-environmental attributes influencing yielding pattern of clones. An overall initial performance analysis has appeared elsewhere (Vinod *et al.*, 1996).

MATERIALS AND METHODS

The details of 15 clones used for this investigation are available in Table 1. The clone trial was established in 1979 at the experimental farm of the Regional Research Station of the Rubber Research Institute of India situated at Taranagar, Agartala (23° 53′ N; 91° 15′ E; 30 m above msl). The

Table 1. Parentage of clones

Clone	Parentage
Indian	
RRII 5	Primary clone
RRII 105	Tjir 1 x Gl 1
RRII 118	Mil 3/2 x Hil 28
RRII 203	PB 86 x Mil 3/2
Malaysian	
Gl 1	Primary clone
RRIM 600	Tjir 1 x PB 86
RRIM 605	PB 49 x Tjir 1
RRIM 703	RRIM 600 x RRIM 500
PB 5/51	PB 86 x PB 24
PB 86	Primary clone
PB 235	PB 5/51 x PB S/78
Indonesian	
GT 1	Primary clone
Liberian	
Harbel 1	Primary clone
Sri Lankan	
RRIC 52	Primary clone
RRIC 105	Tjir 1 x RRIC 52

experiment was laid out in completely randomised design with 40 trees per clone as initial stand. The trees were opened for tapping in 1989. Since the yielding pattern generally shows a low yielding trend during April to September, it is denoted as Regime I, whereas the peak yielding period (October to January) is denoted as Regime II. Yield was collected twice a month by cup coagulation method from June to January. The yield data of 1996-98 period was subjected to analyses to find out the impact of macro-environment attributes.

The per cent yield depression during Regime I was calculated using the formula:

$$\frac{\text{Reduction in yield during Regime I}}{\text{Mean yield during Regime II}} \times 100$$

The yield per cm of the tapping cut was calculated as :

$$\frac{\text{Annual average yield (g/tree/tap)}}{\text{Length of tapping panel (cm)}}$$

Calculation of standard deviation, coefficient of variation, correlation with meteorological attributes, regressions and covariance analyses were done following standard statistical procedures (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

In Tripura the winter is from November to January. The fall in minimum temperature starts from October onwards and reaches the minimum by January. During this period, there is an increase in dry rubber yield, but it declines towards January. On the other hand, the yield during April to September is generally low.

The data on mean girth and yield from BO1 and BO2 panels and mean yield over eight years for the 15 clones are given in Table 2. While RRIC 52 attained maximum girth (91.2 cm), the mean yield was seen to be very low (23.1 g/tree/tap) and PB 235 with a moderate girth (80 cm) exhibited the highest mean yield (47.7 g/tree/tap). In an another study, no correlation was evident between stability variance for girth increment and regression coefficient for yield (Priyadarshan *et al.*, 1998 a&b) pointing that girth increment and yield are two independent attributes. PB 235 is considered as a high yielding clone with its latex containing low sucrose concentrations. Its biosynthetic activity is also reported to be intense with higher values of latex and dry rubber yield and high inorganic phosphorus (Pi) with a rapid regression between two tappings (Jacob *et al.*, 1995). PB 235 does not tend to increase yield significantly at longer tapping intervals and the higher yield of this clone could be due to high metabolic activity of laticifers (Serres *et al.*, 1994). The usefulness of this clone in Tripura can further be confirmed through on-farm trials. The yielding trend of RRII 118 is exceptional with increment in yield on BO2 panel. On the basis of the mean yield over eight years the high yielding clones could be ranked in the order PB 235, RRIM 600, RRII 203 and RRII 118.

The clones RRII 5 and RRII 203 showed least yield depression during Regime I. Estimation of coefficient of variation in dry rubber yield over months revealed RRII 5, RRII 203, PB 235 and GT 1 with lower values indicating least variation. GT 1 is counted as a high yielding clone under the conditions of China (Zongdao and Xueqin, 1983; Zongdao and Yanqing, 1992) but it showed less dry rubber yield in Tripura. Though Tripura and

Table 2. **Mean girth, yield and yield attributes**

Clone	Mean girth (cm)	Yield (g/tree/tap) BO1	Yield (g/tree/tap) BO2	Mean yield over eight years *	Yield depression (%) Regime I**	Coefficient of variation over months	Yield/unit length of tapping cut
Indian							
RRII 5	68.9	20.1	27.7	23.9	14.0	7.56	0.85
RRII 105	73.5	28.9	38.4	33.7	49.9	33.29	1.0
RRII 118	85.3	27.5	45.3	36.4	33.7	20.31	1.07
RRII 203	80.6	32.5	43.7	38.1	18.6	10.25	1.14
Malaysian							
Gl 1	61.2	15.2	17.1	16.3	34.3	20.75	0.44
RRIM 600	76.4	34.8	45.2	40.0	44.2	28.38	0.99
RRIM 605	75.9	25.5	32.5	29.0	50.2	33.69	0.74
RRIM 703	69.0	29.3	39.2	34.3	37.4	23.03	1.21
PB 5/51	66.2	19.7	28.1	23.9	36.2	22.61	0.77
PB 86	72.8	25.8	31.8	28.8	36.8	22.61	0.77
PB 235	80.0	40.3	55.2	47.7	31.9	18.99	1.34
Indonesian							
GT 1	70.1	20.5	30.4	25.4	29.9	17.69	0.85
Liberian							
Harbel 1	66.3	17.5	20.9	19.2	49.6	33.02	0.58
Sri Lankan							
RRIC 52	91.2	19.6	26.6	23.1	38.9	24.19	0.57
RRIC 105	86.0	25.4	30.3	27.8	47.3	30.98	0.59

* g/tree/tap
** Regime I : April to September; Regime II : October to January

rubber growing areas of South China fall under the same latitude range, the disparity in yielding potential can only be attributed to edaphic factors. The clones PB 235, RRIM 703, RRII 203 and RRII 118 exhibited higher yield per unit length of the tapping panel with values more than 1 g dry rubber per cm.

All the clones showed an increment in yield towards the onset of cold season during October-November. It is implicit that the cold weather (18-20°C) is favourable to latex flow and the onset of cold season renders a stimulatory effect and the trend continues till the temperature falls below 15°C during January. The clone PB 235 showed a slow escalation in yield from April onwards and reaching the maximum during November and receding sharply during December. All the other clones yielded very low during April to October, with the peak yield during November and December.

The pattern of PB 235 is desirable since the clone gives considerable yield during Regime I, which ensures better returns to the planter. Since low temperature is believed to be a factor for inducing yield increment, a comparative evaluation of yield potential in relation to weather variables will be worthwhile exercise. When monthly yield of all the clones were correlated with monthly means of minimum temperature, wind velocity and evaporation, all these weather variables showed negative correlation with monthly mean yield (yield *vs.* minimum temperature: -0.7; $P \leq 0.05$; yield *vs.* wind velocity: -0.94; $P \leq 0.01$; yield *vs.* evaporation: -1.0; $P \leq 0.01$), indicating that fall in temperature along with reduced evaporation and low wind speeds prevail upon the micro-environment to influence yield stimulation during October to December. Extrapolations of yield (environmental mean) against wind velocity, evaporation and minimum temperature are presented in Figs. 1 and 2. Though yield of PB 235 showed significant negative correlation with wind velocity (-0.8; $P \leq 0.01$) and evaporation (-1.0; $P \leq 0.01$), it lacked any relation with the minimum temperature. While the environmental mean (g/tree/tap) followed a trend in cognisance with the minimum temperature (Fig. 3), PB 235 was an exception with yield fluctuations over months and years. PB 235 is therefore, less sensitive to fall in minimum temperature and adaptable to the conditions of Tripura.

A regression analysis was carried out involving PB 235 and RRIM 600. Regression of mean dry rubber yield (g/tree/tap) over environmental mean was worked out for the two regimes to find out the threshold yield level, below which a clone experiences stress. The regressions are of cross over type where the meeting points of regression lines for Regime I and Regime II represent the threshold yield level (Ceccarelli, 1989). Accordingly, this threshold level for the clones was 28 g/tree/tap (Fig. 4).

The yielding trends in rubber with a peak yielding period during cool temperature regime is exceptional and is confined to North Eastern states of India. RRII 203 and PB 235 exhibiting a higher yield during non-cold months offer an advantage that near returns over months can be ensured by planting them. When the yielding trends of a few clones (RRII 105, RRII 118, RRII 203, RRIM 600, RRIM 605, PB 86 and PB 235) were evaluated at 600 m msl (Tura, NE India), all clones exhibited two peak yielding periods during June and November (Reju *et al.*, 2000). However, in Tripura, almost all clones exhibited higher yield only during November. This difference is obviously due to difference in macro-environment factors at higher elevations.

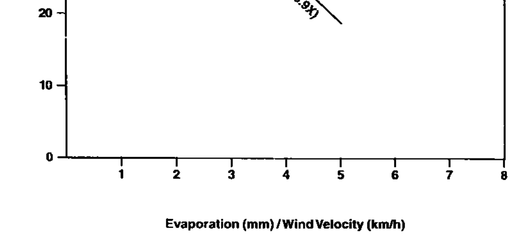

Fig. 1. Regression of mean yield (environmental mean) over evaporation and wind velocity

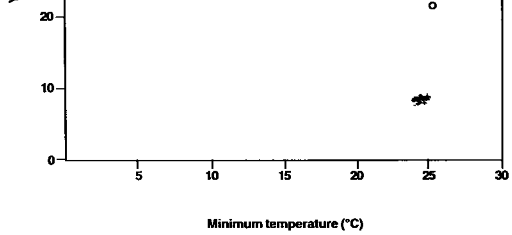

Fig. 2. Regression of mean yield (environmental mean) over minimum temperature

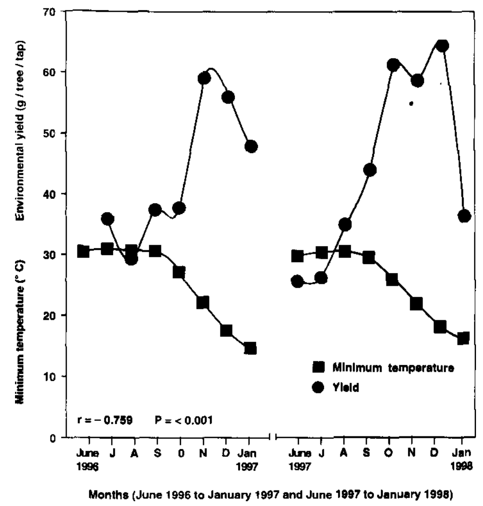

Fig. 3. Depiction of minimum temperature and yeild (g/tree/tap) over two years (1996-98)

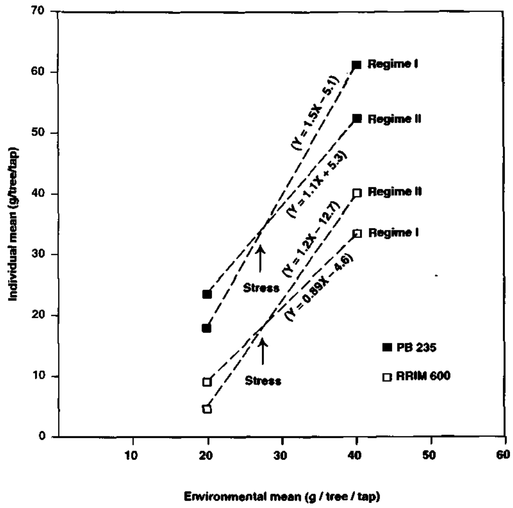

Fig. 4. Regression of mean yield of PB 235 and RRIM 600 over environmental mean yield under two yielding regimes

A comparison of coefficient of variation over months can be had from Table 2. Interestingly, RRII 5 exhibited least variation over the months. However, the annual mean yield over eight years is low rendering it unsuitable to be considered as prominent clone. On the other hand, RRII 118, RRII 203, RRIM 703 and PB 235 are the high yielders with least variations, among which RRII 203 appears most promising in view of the coefficient of variants (10.25) and yield depression (18.6) during Regime II.

Covariance analysis was conducted to compare the yielding potentials under the two yielding regimes (Table 3). The significance of F values ascertained clones to be either consistent or non-consistent. Clones with non-significant F values are considered to be consistent and as such, RRII 5, RRIM 703, PB 5/51 and PB 235 can be counted as consistent. The consistent clones have also exhibited least coefficient of variation over months (Tables 2 and 3). Of these, PB 235 and RRIM 703 showed higher yield over eight years.

The factors that effect the yield depression in Regime I are : 1. prominent winter spell during January there by leading to physiological imbalance, the effect of which will be carried forward, 2. aftereffect of conspicuous defoliation period for more than 15 days (February-March), which is clone specific, 3. prominent moisture deficit during February-March, 4. rainy days during May, June and July, and 5. higher evaporation and wind speeds.

Hence selection of best yielding clone(s) under this regime would indirectly ensure tolerance towards these macro-environmental stresses. Moisture deficit experienced during December-March in Tripura is a crucial factor prevailing over rubber yield.

Many attributes relating to yield need to be considered while exercising selection of clones for commercial cultivation. In the non-traditional environment of Tripura, the attributes which deserve prime attention are mean yield, per cent depression during

Table 3. **Comparison of yielding potentials under two regimes (co-variance analysis)**

Clone	F-value	Significance of F		Consistency
Indian				
RRII 5	2.717	0.144	NS	C
RRII 105	20.334	0.001	S	NC
RRII 118	5.626	0.042	S	NC
RRII 203	6.842	0.028	S	NC
Malaysian				
Gl 1	7.196	0.025	S	NC
RRIM 600	13.813	0.006	S	NC
RRIM 605	10.669	0.011	S	NC
RRIM 703	2.621	0.152	NS	C
PB 5/51	2.824	0.137	NS	C
PB 86	6.565	0.031	S	NC
PB 235	0.410	0.681	NS	C
Indonesian				
GT 1	12.283	0.008	S	NC
Liberian				
Harbel 1	7.849	0.021	S	NC
Sri Lankan				
RRIC 52	7.189	0.026	S	NC
RRIC 105	14.191	0.005	S	NC

NS : Non-significant; S : Significant; NC : Non-consistent; C : Consistent

Regime I, consistency in yield over months and yield per unit length of tapping cut. The clones yielding more than 1 g per cm of tapping cut can be considered as high yielding. A regression analysis involving individual mean yield and environmental yield proved that clones yielding more than 28 g/tree/tap shall not be experiencing stress in this environment. When all these attributes are taken into consideration, the clones selected for block evaluation trials are PB 235, RRII 203, RRIM 703 and RRII 118.

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