PATH ANALYSIS OF YIELD AND MAJOR YIELD COMPONENTS OF *HEVEA BRASILIENSIS* CLONE RRIM 600 UNDER ENVIRONMENTAL CONDITIONS OF TRIPURA

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The effect of environment, nutrition and tapping systems on yield and yield components of the clone RRIM 600 was studied during peak yielding months at Agarthala, India. Path analysis performed to understand the cause-effect relationship of different yield components revealed the influence of weather parameters. The temperature is the most important climatic parameter directly affecting the flow rate, dry rubber content and plugging of the latex vessels. Wind speed and pan evaporation also affected the rubber content in the latex and plugging of vessels. Other parameters like length of tapping cut, systems of tapping and tapping panel have significant influence on yield. Application of chemical stimulant (2.5% ethepon) also increased yield during low yielding period. Yield also increased with increase in nitrogen dose up to 30 kg/ha. The effects of all these factors on yield either by contributing towards DRC or by affecting the flow rate which ultimately causes early plugging and low yield are discussed.

Key words: *Hevea*, Nitrogen, Non-traditional area, Path analysis, Tapping panels, Yield components.

In India, rubber cultivation has been expanded to non-traditional regions due to limited scope of further expansion in traditional area. North East (NE) India is one of the non-traditional areas where rubber cultivation has been undertaken in an area of 50,000 ha. The popular high yielding *Hevea brasiliensis* clone RRIM 600 has been largely planted in this region, where climatic extremes like summer and winter influence the yield considerably (Alam *et al.*, 2003). Under such climatic conditions *H. brasiliensis* presents two yielding regimes (Priyadarshan *et al.*, 2000), a low yielding period (April to September) and a peak yielding period (October to January). About 60 per cent of the annual yield is obtained during the peak yielding period (Vinod *et al.*, 1996).

Yield in rubber is influenced by four major components *viz.*, length of tapping cut, initial flow rate, dry rubber content and plugging index (Sethuraj, 1981). It is also affected by several other factors like weather, phenology of plant, tapping system, nutrition and chemical stimulation (Jacob *et al.*, 1989). The influence of these factors on different components varies, thereby changing the overall response in terms of yield. However, information on the factors affecting the major yield components in the non-traditional areas is scanty. Hence the effect of environment, nutrition, tapping systems and other plant factors of the clone RRIM 600 on yield and yield components during

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the peak yielding month was studied.

The study was carried out at experimental farm of Regional Station of Rubber Research Institute of India, Taranagar, Agartala (23° 53′ N; 91° 15′ E 20 msl). The experimental plot was planted with clone RRIM 600 during 1986 and the trees were tapped on ½ S d/2 7d system since 1994. The major yield components like initial flow rate (F), plugging index (P), dry rubber content (Cr) and yield were recorded from 30 trees at monthly intervals from June 1998 to January 2000 except the rest period (February, March and April 1999). The effect of other factors like length of tapping cut (l), panel under tapping, tapping system adopted and the level of nitrogen fertilizer application were studied in other plantations / experimental plots within the farm with the clone RRIM 600, during peak yielding month. Ten trees having similar girth per treatment were selected from such plantations and the observations were repeated for two times during November. To study the effect of stimulation, the chemical stimulant Ethephon (2.5%) was applied on the panel two days before tapping. The initial flow rate per minute was recorded during first five minutes after tapping and P was calculated as per the Milford *et al.* (1969). The Cr was determined by gravimetric method. The yield (g/tree/tap) was computed by multiplying dry rubber content with volume of latex harvested from single tapping from a tree once in a month. Weather parameters were collected from the meteorological observatory of the farm and the data were analyzed statistically.

Weather condition of the region during the study period is presented in Fig. 1. The mean annual rainfall of this region was

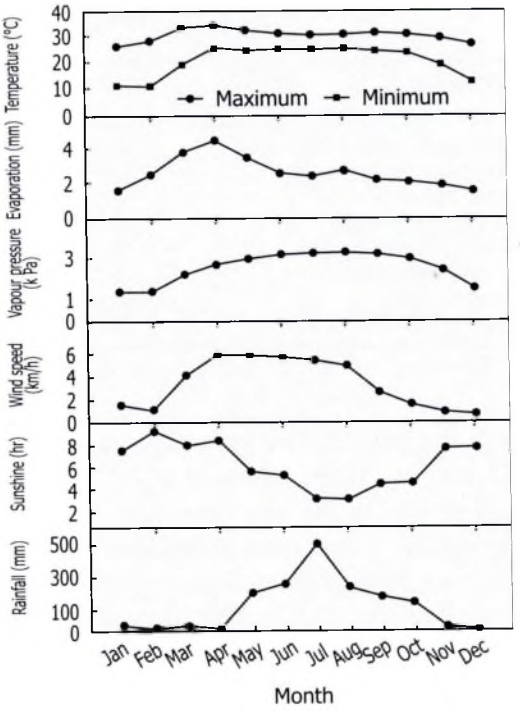

Fig. 1. Weather parameters (mean of two years – 1998 and 1999) at Agartala

1654 mm. The minimum temperature varied from 11°C to 26°C. The influence of weather parameters could be mediated through their effects on various yield components.

The mean yield varied from 21 to 76 g/tree/tap during the different months (Fig. 2) and showed a peak during November. Initial flow rate (F) ranged from 0.076 to 0.13 ml/cm/min. The correlation between F and yield was not significant but that of Cr and P was significant. However, the maximum (T_{max}), and minimum (T_{min}) temperature, wind speed (WS), relative humidity, evaporation (EV), rainfall and vapour pressure showed positive correlation with F and Cr (Table 1). Positive relation of T_{min}

Table 1. **Correlation of yield and major yield components of clone RRIM 600 and weather parameters of Agartala**

Parameter	Yield	Initial flow rate (F)	Dry rubber content (Cr)	Plugging index (P)
Maximum temperature (°C)	-0.365	0.928**	0.965**	0.808**
Minimum temperature (°C)	-0.316	0.940**	0.965**	0.752*
Wind speed (km/h)	-0.762*	0.773**	0.838**	0.887**
Sunshine hours (h)	0.358	-0.716*	-0.747*	-0.626
Relative humidity (%)	-0.140	0.793**	0.832**	0.536
Evaporation (mm)	-0.772**	0.635*	0.683*	0.903**
Rainfall (mm)	-0.545	0.654*	0.724*	0.663*
Vapour pressure (k Pa)	-0.280	0.919**	0.949**	0.712*

** Significant at P≤0.01; * Significant at P≤0.05

with F (Table 2) has been reported earlier (Dey *et al.*, 1999; Vinod *et al.*, 2000). It may be due to the easy availability of water during low temperature period that enhance the latex flow by decreasing evapotranspiration (Shangpu, 1986). The effect of weather attributes on yield and other components have been reported for the clone RRII 105 and other hybrids from the traditional rubber growing region of India (Rao *et al.*, 1998; Sailajadevi *et al.*, 2000).

The mean Cr varied from 20 to 42 per cent (Fig. 2). A positive correlation between Cr, F and P was found but not with yield. All weather parameters were positively correlated with Cr except sunshine hours, which showed a negative correlation (Table 1). However, in the path analysis maximum temperature was found to have direct significant and highest positive effect on Cr (Table 2). The WS also showed positive and significant effect on Cr. High Cr led to an increase in latex viscosity, hindering the flow and thus limited the yield. High temperature resulted in high evapo-transpiration (Jacob *et al.*, 1989), which in combination with high wind speed leads to cessation of latex flow (Lee and Tan, 1979) causing early plugging (TCRI, 1986).

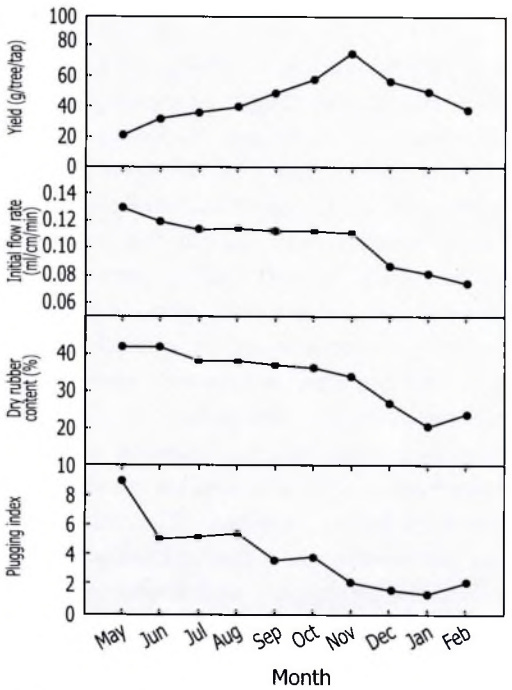

Fig. 2. Variation in yield and yield components (average of two years) for the clone RRIM 600 under ½ S d/2 system of tapping

Wide variation in P was observed during different months of the year (Fig. 2). As expected, P showed negative correlation with yield. All the weather parameters showed significant positive correlation with P except sunshine hours and relative humidity (Table 1). The EV has the direct positive signifi-

Table 2. **Direct (diagonal elements) and indirect effects of weather parameters on major yield components of clone RRIM 600 at Agartala**

On initial flow rate (F)				
	T_{min}	WS	EV	r
T_{min}	0.902**	-0.069	0.107	0.940**
WS	0.712	-0.088	0.149	0.773**
EV	0.520	-0.071	0.186	0.635*
On dry rubber content (Cr)				
	T_{max}	WS	EV	r
T_{max}	0.842**	0.316	-0.193	0.965**
WS	0.625	0.426**	-0.213	0.838**
EV	0.610	0.340	-0.267**	0.683*
On plugging index (P)				
	T_{max}	WS	EV	r
T_{max}	0.196	0.275	0.337	0.808**
WS	0.145	0.370	0.372	0.887**
EV	0.141	0.296	0.466*	0.903**

T_{min} = Minimum temperature; T_{max} = Maximum temperature; WS = Wind speed; EV = Evaporation.
Residual for flow rate = 0.319, R^2 = 0.898
Residual for dry rubber content = 0.116, R^2 = 0.986
Residual for plugging index = 0.304, R^2 = 0.908

cant effect on P (Table 2). A high seasonal variation of P has been reported (Chandrasekhar *et al.*, 1993; Vinod *et al.*, 2000). An inverse relation of P with yield has also been reported (Waidyanatha *et al.*, 1971; Dey *et al.*, 1999; Vinod *et al.*, 2000). It could be explained that due to high evaporation flow stops early leading to plugging. The yield also increased under high dose of nitrogen application (Table 3). It increased up to 40 per cent with application of 30 kg N per ha compared to zero nitrogen application. However, the subsequent increase with increase in N application was not significant. An increasing trend of F and decreasing trend of Cr were also noticed without major change in P with increase in N.

Out of four major yield contributing parameters, the length of tapping cut (l) has significant contribution to the yield. The yield increased with increase in l while Cr, P and F decreased (Fig. 3). A two-fold increase in yield was observed when the stimulant (ethephon) was applied by panel application two days before tapping in October. The yield varied under different systems of tapping. Yield per tree per tap increased with reduction in frequency of tapping (Table 3). It increased up to 10 per cent in the d/3 system and 20 per cent in the d/4 system of tapping compared to that of d/2 system during November. Cr did not show any significant difference, with increase in frequency of tapping. P and F also showed a decreasing trend.

The yield was observed to be affected by different tapping panels (Table 3). In comparison to BO1 panel, yield was high (12%) in BO2 and less (7%) in BI1. Reduction in yield in BI1 panel may be due to

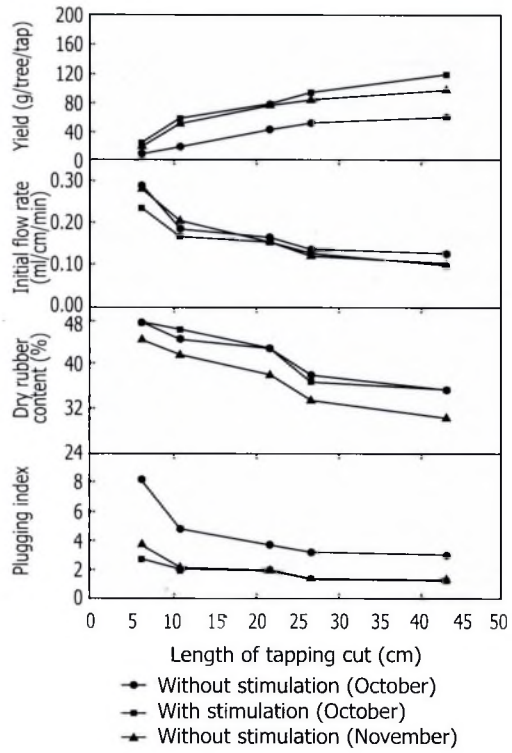

Fig. 3. Effect of stimulation on yield and yield components with varying lengths of tapping cut under ½ S d/3 system of tapping

regeneration of new bark that reduced the flow rate and subsequently increased the plugging. Interestingly Cr was not affected by change of tapping panel.

To know the cause-effect relationships of different parameters the path analysis was performed and presented in the Tables 2, 4 and 5. It is observed that the different weather parameters have direct or indirect effects on individual yield components and yield. In season based analysis, the path coefficient values of F and P exceeded one. Multicollinearity might have caused such inflated value (Williams *et al.*, 1990), which indicates that weather has affected other factors also besides the yield components. Analysis on effect of weather variables with individual yield components showed highest direct significant and positive effect of T_{min} on F, T_{max} on Cr and EV on P, where I is not taken as a variable.

The path analysis study of I showed that it has direct and significant positive effect on yield (Table 4) while P has a

Table 3. **Change of yield and yield components under different nitrogen doses, tapping systems and in tapping panels**

	Yield (g/tree/tap)	Initial flow rate (F) (ml/cm/min)	Dry rubber content (Cr) (%)	Plugging index (P)
Nitrogen doses (under ½ S d/3 system of tapping)				
N0	109 ± 6.9	0.086 ± 0.007	3.15 ± 0.96	1.25 ± 0.05
N30	152 ± 12.0	0.102 ± 0.006	30.3 ± 0.91	1.04 ± 0.04
N60	178 ± 12.4	0.110 ± 0.006	29.6 ± 0.66	0.97 ± 0.07
Tapping systems				
½ S d/2	49.8 ± 6.2	0.103 ± 0.008	34.3 ± 1.4	3.38 ± 0.23
½ S d/3	54.7 ± 6.0	0.126 ± 0.008	35.6 ± 1.0	2.89 ± 0.40
½ S d/4	59.5 ± 7.1	0.139 ± 0.01	37.2 ± 1.3	2.72 ± 0.3
Tapping panels (under ½ S d/2 system of tapping)				
BO1	62.9 ± 3.9	0.065 ± 0.006	25.8 ± 1.2	2.20 ± 0.18
BO2	70.4 ± 4.0	0.070 ± 0.005	25.8 ± 1.5	1.80 ± 0.21
BI1	58.6 ± 3.6	0.047 ± 0.003	26.0 ± 1.8	2.30 ± 0.29

Table 4. **Direct (diagonal) and indirect effect of major yield components on yield with and without stimulation**

	Length of tapping cut (l)	Initial flow (F)	Dry rubber content (Cr)	Plugging index (P)	r
Without stimulation (October)					
l	0.758**	-0.157	-0.088	0.331	0.844**
F	-0.538	0.22	0.072	-0.322	-0.567**
Cr	-0.659	0.156	0.101	-0.305	-0.707**
P	-0.512	0.145	0.063	-0.489**	-0.793
With stimulation (October)					
l	0.576**	-0.073	0.067	0.276	0.846**
F	-0.472	0.088	-0.060	-0.262	-0.706**
Cr	-0.508	0.070	-0.075	-0.270	-0.783**
P	-0.357	0.052	-0.046	-0.444**	-0.795**
Without stimulation (November)					
l	0.481*	0.011	-0.035	0.440	0.897**
F	-0.36	-0.015	0.024	-0.404	-0.755**
Cr	-0.437	-0.009	0.039	-0.493	-0.900**
P	-0.374	-0.011	0.034	-0.567**	-0.9188*

Residual without stimulation (October) = 0.410, R^2 = 0.831
Residual with stimulation (October) = 0.402, R^2 = 0.838
Residual without stimulation (November) = 0.265, R^2 = 0.929
*Significant at P≤ 0.05; ** Significant at P ≤ 0.01

Table 5. **Direct (diagonal) and indirect effects of major yield components on yield under different conditions in clone RRIM 600**

	Initial flow (F)	Dry rubber content (Cr)	Plugging index (P)	r
Season				
F	1.787**	-0.916	-1.169	-0.298
Cr	1.725	-0.949	-1.165	-0.389
P	1.469	-0.778	-1.422**	-0.731*
Nitrogen				
F	0.822**	-0.010	-0.148	0.664**
Cr	-0.256	0.031	0.020	-0.204
P	0.190	-0.001	-0.644**	-0.455*
Tapping system				
F	0.233	0.001	0.520	0.755**
Cr	0.020	0.017	0.107	0.144
P	-0.181	-0.003	-0.669**	-0.853**

Residual for season = 0.354, R^2 = 0.875
Residual for nitrogen = 0.408, R^2 = 0.832
Residual for tapping system = 0.500, R^2 = 0.750
*Significant at P≤ 0.05; ** Significant at P ≤ 0.01

negative effect. The effects of F and Cr were not appreciable. Similar results were observed with or without application of stimulant in the month of October and in the peak yielding month. Under the different nitrogen doses the P had significant negative effect on yield. Besides the weather factors, increase in yield was influenced by increase of length of tapping cut, nitrogen application, stimulant application, change of tapping system and panel. Most of the factors that increased dry rubber content or decreased the flow of latex directly or indirectly contributed to early plugging and low yield. The release of one limitation is resulted in an increase of yield up to a certain point at which again it is limited by another factor. Hence modification of all these limiting factors simultaneously may help in breaking the yield barrier.

REFERENCES

Alam, B., Das, G., Raj, S., Roy, S., Pal, T.K. and Dey, S.K. (2003). Studies on yield and biochemical sub-components of latex of rubber trees (*Hevea brasiliensis*) with a special reference to the impact of low temperature in a non-optimal environment. *Journal of Rubber Research*, **6**(4) : 241-257.

Chandrashekar, T.R., Vijayakumar, K.R. and Sethuraj, M.R. (1993). Variations in yield and other physiological characteristics of two *Hevea* clones in North Konkan. *Indian Journal of Natural Rubber Research*, **6**(1&2) : 156-158.

Dey, S.K., Vijayakumar, K.R., Nair, D.B. and Subramanian, P. (1999). Effect of temperature and vapour pressure on major yield components of rubber in humid and dry sub-humid climatic regions. *Indian Journal of Natural Rubber Research*, **12**(1&2) : 69-76.

Jacob, J.L., Prevot, J.C., Roussel, D., Lacrotte, R., Serres, E., d'Auzac, J., Eschbach, J.M. and Omont, H. (1989). Yield limiting factors, latex physiological parameters, latex diagnosis and clonal typology. In: *Physiology of Rubber Tree Latex.* (Eds. J. d'Auzac and H. Chrestin). CRC Press Inc., Florida, pp. 345-382.

Lee, C.K. and Tan, H. (1979). Daily variation in yield and dry rubber content in four *Hevea* clones. *Journal of the Rubber Research Institute of Malaysia*, **27** : 117-126.

Milford, G.F.J., Paardekooper, E.C. and Ho Chai Yee (1969). Latex vessel plugging, its importance to yield and clonal behaviour. *Journal of the Rubber Research Institute of Malaya*, **21**(3) : 274-282.

Priyadarshan, P.M., Sudhasowmyalatha M.K. Sasikumar, S., Dey, S.K. and Varghese, Y.A. (2000). Evaluation of *Hevea brasiliensis* clones for yielding trends in Tripura. *Indian Journal of Natural Rubber Research*, **13**(1&2) ; 56-63.

Rao, P.S., Saraswathyamma, C.K. and Sethuraj, M.R. (1998). Studies on the relationship between yield and meteorological parameters of para rubber tree (*Hevea brasiliensis*). *Agricultural and Forest Meteorology*, **90**: 235-245.

Sailajadevi, T., Nair, R.B., Dey, S.K., Devakumar, A.S., Licy, J., Kothandaraman, R. and Sethuraj, M.R. (2000). Impact of weather on yield and yield components in some elite *Hevea* clones. *Indian Journal of Natural Rubber Research*, **13**(1&2) : 98-102.

Sethuraj, M.R. (1981). Yield components in *Hevea brasiliensis* : Theoretical considerations. *Plant Cell and Environment*, **4** : 81-83.

Shangpu, L. (1986). Judicious tapping and stimulation based on dynamic analysis of latex production. *Proceedings, IRRDB Rubber Physiology and Exploitation Meeting*, SCATC, Hainan, China, pp. 230-239.

TCRI (1986). Latex production pattern under earlier reopening in Yunnan province. *Proceedings of the IRRDB Rubber Physiology and Exploitation Meeting*, 1986. Tropical Crops Research Institute, Hainan, China, pp. 209-222.

Vinod, K.K., Meenattoor, J.R., Priyadarshan, P.M., Pothen, J., Choudhuri, D., Krishnakumar, A.K., Sethuraj, M.R. and Potty, S.N. (1996). Early performance of some clones of *Hevea brasiliensis* in Tripura. *Indian Journal of Natural Rubber Research*, **9**(2) : 123-129.

Vinod, K.K., Pothen, J., Choudhuri, D., Priyadarshan, P.M., Eappen, T., Varghese, M., Mandal, D., Sharma, A.C., Pal, T.K., Devakumar, A.S. and Krishnakumar, A.K. (2000). Variation and trend of yield and related traits of *Hevea brasiliensis* Muell. Arg. in Tripura. *Indian Journal of Natural Rubber Research*, **13**(1&2) :69-78.

Waidyanatha, U.P., De, S. and Pathiratne L.S.S. (1971). Studies on latex flow patterns and plugging indices of clones. *Quarterly Journal, Rubber Research Institute of Ceylon*, **48** : 47-55.

Williams, W.A., Jones, M.B. and Demment, M.W. (1990). A concise table for path analysis statistics. *Agronomy Journal*, **82** : 1022-1024.