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EFFECT OF TEMPERATURE AND VAPOUR PRESSURE ON MAJOR YIELD COMPONENTS OF RUBBER IN HUMID AND DRY SUB-HUMID CLIMATIC REGIONS

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Attempts were made to study the effects of temperature and vapour pressure on major yield components of *Hevea brasiliensis* in humid and dry sub-humid climates. Initial flow rate (F) is positively and plugging index (P) and dry rubber content (Cr) are negatively correlated with yield in both the climatic regions. Maximum temperature (T_{max}) showed a negative correlation and minimum temperature (T_{min}) and Vapour pressure (VP) positive correlations with initial flow rate, whereas T_{max} correlated positively with P and Cr.

Key words : Dry rubber content, *Hevea brasiliensis*, Initial flow rate, Plugging index, Temperature, Vapour pressure.

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INTRODUCTION

The production potential of any crop is an integrated effect of all environmental conditions. Rubber, being a perennial crop, has a long economic life span undergoing environmental interaction which manifests variation in yielding pattern. Monthly variation in yield is quite common even under the same number of tapping days per month. The variation in yield may be due to physiological and biochemical changes which are regulated by climatic factors.

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). These components are controlled by environmental factors (Rao *et al.*, 1990). The length of tapping cut is determined by the girth which is predominantly a clonal character and is influenced by the total biomass production and its partitioning between growth and latex production. Since the length of tapping cut can be manipulated by adopting different systems of exploitation, this parameter was not included in this study. The effect of climatic parameters on girth is well known (Dey *et al.*, 1996; 1998). Though the interrelationships between yield and yield contributing parameters and other associated characters were earlier elucidated, the effect of climatic parameters were not studied. From earlier studies (Saraswathyamma and Sethuraj, 1975; Yeang and Paranjothy, 1982), it has been found that approximately 45 per cent and 20 per cent of variation in yield can be explained due to latex vessel plugging index and initial flow rate respectively. The objective of this study is to assess the effects of temperature and vapour pressure on these three major yield components under two climatic regimes.

MATERIALS AND METHODS

Experiments were conducted at the Central Experiment Station, Chethackal (9.22°N, 76.50°E, 80 m above msl), Kerala state (humid climate) and at the Regional Research Station, Dapchari (20.04°N, 72.04°E, 48 m msl), Maharashtra state (dry sub-humid climate) of the Rubber Research Institute of India. The fields selected for the study were planted with nine clones *viz.*, PB 235, RRII 300, GT 1, RRIM 501, Gl 1, RRIM 612, Tjir 1, PR 107 and RRIM 600 during 1982. The trees were tapped following the 1/2S d/2 6d/7 system from 1991. Yield was recorded from 25 trees by cup coagulation method for three years and initial flow rate (F), plugging index (P) and dry rubber content (Cr) were recorded from four trees per clone at monthly intervals for a period of 18 months. The initial flow rate per minute (F) was measured during the first five minutes after tapping and P was calculated as per Milford *et al.* (1969). Percentage of dry rubber contained in the latex (Cr) was estimated. The average vapour pressure (VP), maximum temperature (T_{max}) and minimum temperature (T_{min}) recorded from both the stations are presented in Fig. 1. The relationship of maximum and minimum temperatures and vapour pressure to yield components were worked out from the monthly mean data of the nine clones. Correlation coefficients for individual clones were also worked out and the relation of yield components with the above parameters expressed in linear multiple regression equations.

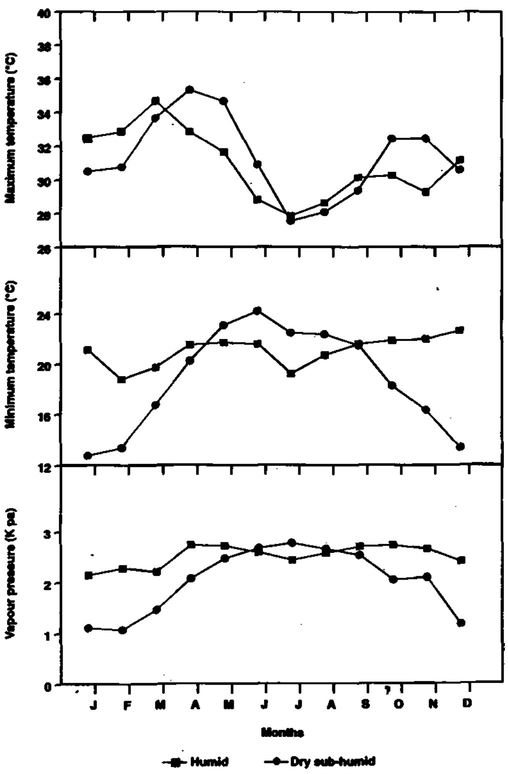

Fig.1. Monthly variations in temperature and vapour pressure at the humid (-■-) and dry sub-humid (-●-) locations

RESULTS AND DISCUSSION

Large variation in yield among *Hevea* cultivars was noticed throughout the year in both the locations. Mean monthly yield of nine clones varied from 14.6 to 27.2 and 18.4 to 40 g per tree per tap in dry sub-humid and humid locations respectively (Fig. 3). Average yield of three years showed that in sub-humid climate, clone RRIM 600 was yielding higher whereas PB 235 recorded higher yield in humid climate (Fig. 4). The average number of tapping days per year over three years was 127 for the sub-humid and 145 for the humid regions. The annual

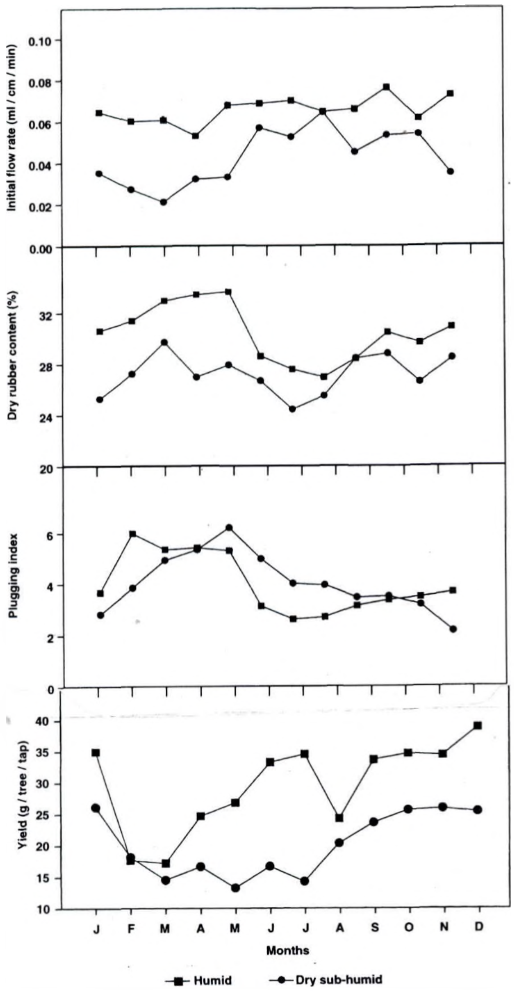

Fig. 2. Monthly variation in yield and yield components (average of nine clones) in the humid (-■-) and dry sub-humid (-●-) locations

mean yield of all the nine clones over three years was 838 and 1348 kg per 300 trees per year in dry sub-humid and humid locations respectively.

Annual average girth increment over the three year period for all clones showed an increment of 3.4 cm in humid and 2.4 cm in the dry sub-humid locations. Clones GT 1 and RRIM 612 showed higher girth increment in humid and dry sub-humid climate on tapping (Fig. 3). The relation of environmental parameters with growth of rubber was reported by Dey *et al.* (1998). Moraes (1977) reported that a mean annual temperature of 20°C is considered to be the lower limit of thermal adaptation of rubber. Growth retardation was reported when mean monthly temperature dropped below 18°C (Jiang, 1984).

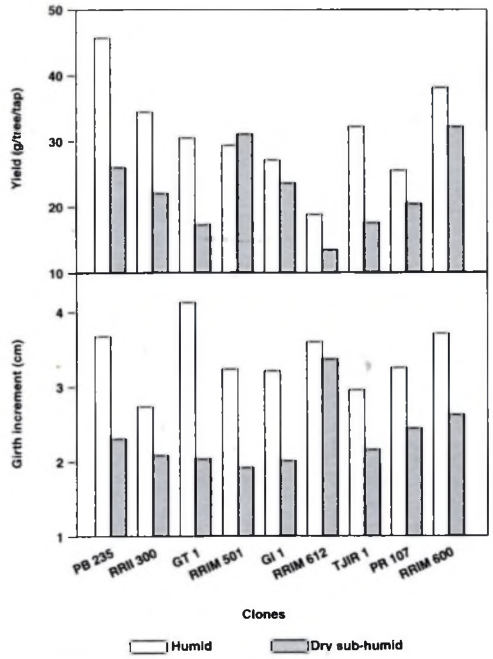

Fig.3. Yield and girth increment (average of three years) of nine clones in the humid and dry sub-humid locations

Table 1. **Correlation of yield (average of all clones) with major yield components in the humid and dry sub-humid locations**

Location	F	Cr	P
Dry sub-humid	0.613**	-0.220	-0.708**
Humid	0.762**	-0.560*	-0.867**
Combined	0.875**	-0.174	-0.446**

F = Initial flow rate, Cr = Dry rubber content, P = Plugging index; ** Significant at $P \leq 0.01$; * Significant at $P \leq 0.05$; n = 18, (Combined n = 36)

Table 2. **Correlations among major yield components and meteorological parameters in the humid and dry sub-humid locations**

Parameter	F	Cr	P	T_{max}	T_{min}
Dry sub-humid					
Cr	-0.380				
P	-0.193	0.133			
T_{max}	-0.295	0.522*	0.468*		
T_{min}	0.475*	-0.075	0.560*	0.001	
VP	0.645**	-0.200	0.368	-0.118	0.931**
Humid					
Cr	0.322				
P	-0.631**	0.772**			
T_{max}	-0.637**	0.645**	0.794**		
T_{min}	0.337	0.127	-0.104	-0.003	
VP	0.389	0.031	-0.152	-0.353	0.591**
Combined					
Cr	0.265				
P	-0.215	0.517**			
T_{max}	-0.490**	0.307	0.582**		
T_{min}	0.609**	0.285	0.285	-0.142	
VP	0.720**	0.272	0.183	-0.284	0.927**

F = Initial flow rate, Cr = Dry rubber content, P = Plugging index, VP = Vapour pressure,
T_{max} = Maximum temperature, T_{min} = Minimum temperature.
** Significant at $P \leq 0.01$; * Significant at $P \leq 0.05$; * n=18, (Combined n = 36)

Table 3. **Clone wise multiple regression (R^2) of plugging index (P) and maximum (T_{max}) minimum temperature (T_{min}) in the humid and dry sub-humid locations**

Clone	Regression equation	R^2
Dry sub-humid		
PB 235	$P = 0.416 + 0.043\ T_{max} + 0.004\ T_{min}$	0.291
RRII 300	$P = 1.64 + 0.068\ T_{max} + 0.14\ T_{min}$	0.547
GT 1	$P = -10.8 + 0.246\ T_{max} + 0.324\ T_{min}$	0.910**
RRIM 501	$P = -6.15 + 0.22\ T_{max} + 0.08\ T_{min}$	0.651*
Gl 1	$P = -8.92 + 0.192\ T_{max} + 0.032\ T_{min}$	0.932**
RRIM 612	$P = -24.49 + 0.764\ T_{max} + 0.304\ T_{min}$	0.669*
Tjir 1	$P = -4.97 + 0.290\ T_{max} + 0.04\ T_{min}$	0.384
PR 107	$P = -1.76 + 0.16\ T_{max} + 0.06\ T_{min}$	0.220
RRIM 600	$P = -7.11 + 0.23\ T_{max} + 0.119\ T_{min}$	0.856**
All clones	$P = -6.48 + 0.22\ T_{max} + 0.142\ T_{min}$	0.730**
Humid		
PB 235	$P = -2.16 + 0.25\ T_{max} - 0.146\ T_{min}$	0.573*
RRII 300	$P = -15.19 + 0.70\ T_{max} - 0.144\ T_{min}$	0.725**
GT 1	$P = -8.92 + 0.481\ T_{max} - 0.130\ T_{min}$	0.609*
RRIM 501	$P = -5.17 + 0.421\ T_{max} - 0.244\ T_{min}$	0.813**
Gl 1	$P = -14.6 + 0.517\ T_{max} + 0.128\ T_{min}$	0.629*
RRIM 612	$P = -29.0 + 1.33\ T_{max} - 0.310\ T_{min}$	0.770**
Tjir 1	$P = -25.7 + 1.13\ T_{max} - 0.243\ T_{min}$	0.841**
PR 107	$P = -10.0 + 0.543\ T_{max} - 0.102\ T_{min}$	0.688**
RRIM 600	$P = -6.77 + 0.511\ T_{max} - 0.260\ T_{min}$	0.836**
All clones	$P = -11.9 + 0.590\ T_{max} - 0.135\ T_{min}$	0.810**
Combined	$P = -10.8 + 0.35\ T_{max} + 0.135\ T_{min}$	0.690**

** Significant at $P \leq 0.01$; * Significant at $P \leq 0.05$

Table 4. **Clonewise multiple regression of flow rate (F) and maximum (T_{max}) minimum temperature (T_{min}) in the humid and dry sub-humid locations**

Clone	Regression equation	R^2
Dry sub-humid		
PB 235	$F = 0.167 - 0.003\,T_{max} - 0.006\,T_{min} + 0.05\,VP$	0.641*
RRII 300	$F = 0.068 - 0.001\,T_{max} - 0.002\,T_{min} + 0.02\,VP$	0.644*
GT 1	$F = 0.027 + 0.001\,T_{max} - 0.008\,T_{min} + 0.06\,VP$	0.822**
RRIM 501	$F = 0.032 + 0.001\,T_{max} - 0.004\,T_{min} + 0.04\,VP$	0.740**
GI 1	$F = 0.112 + 0.002\,T_{max} - 0.001\,T_{min} + 0.03\,VP$	0.737**
RRIM 612	$F = 0.030 + 0.001\,T_{max} + 0.001\,T_{min} - 0.004\,VP$	0.230
Tjir 1	$F = 0.108 - 0.001\,T_{max} - 0.008\,T_{min} + 0.06\,VP$	0.769**
PR 107	$F = 0.075 - 0.002\,T_{max} + 0.002\,T_{min} - 0.002\,VP$	0.602
RRIM 600	$F = 0.127 - 0.001\,T_{max} - 0.005\,T_{min} + 0.03\,VP$	0.304
All clones	$F = 0.066 - 0.001\,T_{max} - 0.003\,T_{min} + 0.03\,VP$	0.740**
Humid		
PB 235	$F = 0.098 - 0.002\,T_{max} - 0.0009\,T_{min} + 0.003\,VP$	0.703*
RRII 300	$F = 0.206 - 0.004\,T_{max} - 0.0002\,T_{min} + 0.002\,VP$	0.497
GT 1	$F = 0.056 - 0.003\,T_{max} - 0.002\,T_{min} + 0.02\,VP$	0.497
RRIM 501	$F = 0.105 - 0.001\,T_{max} - 0.0003\,T_{min} + 0.005\,VP$	0.324
GI 1	$F = 0.154 - 0.004\,T_{max} + 0.001\,T_{min} + 0.02\,VP$	0.499
RRIM 612	$F = 0.298 - 0.008\,T_{max} + 0.004\,T_{min} - 0.008\,VP$	0.564
Tjir 1	$F = 0.180 - 0.009\,T_{max} + 0.004\,T_{min} + 0.05\,VP$	0.928**
PR 107	$F = 0.261 - 0.005\,T_{max} + 0.001\,T_{min} - 0.006\,VP$	0.580
RRIM 600	$F = 0.188 - 0.005\,T_{max} + 0.001\,T_{min} + 0.001\,VP$	0.617
All clones	$F = 0.172 - 0.005\,T_{max} + 0.001\,T_{min} + 0.01\,VP$	0.699
Combined	$F = 0.115 - 0.003\,T_{max} - 0.001\,T_{min} + 0.03\,VP$	0.784**

** Significant at $P \leq 0.01$; * Significant at $P \leq 0.05$.

Initial flow rate varied from 0.029 to 0.079 ml per cm per min in sub-humid climate and 0.066 to 0.092 ml per cm per min in humid climate. More variation was noticed in the dry sub-humid than in the humid location (Fig. 2). Initial flow rate showed a significant positive correlation with yield (Table 1), which is in conformity with an earlier report (Mydin *et al.*, 1992). Maximum temperature was negatively correlated with F, whereas, minimum temperature and vapour pressure were positively correlated with F at both the locations (Table 2). Higher T_{max} appears to be unfavourable for the flow of latex. Clones may vary in their sensitivity to temperature variation but in general, there is a lower and an upper limit beyond which growth and production are affected. When moisture becomes a limiting factor, high temperature promotes evapotranspiration and limits water required for latex flow (Jacob *et al.*, 1989). Low temperature may increase the availability of water and enhance latex flow by decreasing evapo-transpiration (Shangpu, 1986). Plugging index varied from 1.73 to 6.20 in the dry sub-humid location and 2.25 to 5.94 in the humid (Fig. 2) and was found to be negatively correlated with yield (Table 1). T_{max} showed a significant positive cor-relation with P whereas, T_{min} did not show any consistent trend (Table 2).

Table 5. **Clonewise linear regression of maximum temperature (T_{max}) on dry rubber content (Cr) in the humid and dry sub-humid locations**

Clone	Regression equation	R^2
Dry sub-humid		
PB 235	Cr = 16.90 + 0.355 T_{max}	0.254
RRII 300	Cr = 24.41 + 0.285 T_{max}	0.247
GT 1	Cr = 14.9 + 0.482 T_{max}	0.402
RRIM 501	Cr = 9.10 + 0.691 T_{max}	0.472
GI 1	Cr = 15.4 + 0.391 T_{max}	0.369
RRIM 612	Cr = 29.8 + 0.089 T_{max}	0.106
Tjir 1	Cr = 6.73 + 0.803 T_{max}	0.633**
PR 107	Cr = 19.9 + 0.376 T_{max}	0.386
RRIM 600	Cr = -3.02 + 1.00 T_{max}	0.664**
All clones	Cr = 15.27 + 0.386 T_{max}	0.522*
Humid		
PB 235	Cr = 1.128 + 1.067 T_{max}	0.635**
RRII 300	Cr = 1.356 + 1.092 T_{max}	0.799**
GT 1	Cr = 6.481 + 0.860 T_{max}	0.607**
RRIM 501	Cr = -5.92 + 1.238 T_{max}	0.696**
GI 1	Cr = 4.019 + 0.967 T_{max}	0.710**
RRIM 612	Cr = 2.17 + 1.04 T_{max}	0.536*
Tjir 1	Cr = 0.110 + 1.09 T_{max}	0.706**
PR 107	Cr = 3.13 + 0.993 T_{max}	0.599**
RRIM 600	Cr = -13.4 + 1.45 T_{max}	0.728 **
All clones	Cr = 4.84 + 0.825 T_{max}	0.645**
Combined	Cr = 18.1 + 0.350 T_{max}	0.307

** Significant at $P \le 0.01$; * Significant at $P \le 0.05$

Plugging in *Hevea* is controlled by a number of physiological and biochemical parameters and has been related to soil moisture con-tent (Saraswathyamma and Sethuraj, 1975; Dey *et al.*, 1995). Plugging index, which display very marked seasonal variation, is a clonal character (Paardekooper and Samosorn, 1969; Saraswathyamma and Sethuraj, 1975) inversely related with yield (Waidyantha and Pathiratne, 1971). Dry rubber content varied from 24.6 to 30.6 per cent in dry sub-humid and 27.5 to 34.9 per cent at the humid location (Fig. 2). Cr showed a negative trend with yield in both the locations (Table 1). T_{max} showed positive correlation with Cr in both the climatic regimes and Cr increased with increase in temperature. High Cr leads to an increase in latex viscosity and thus hinders flow and limits production. High temperature results in high evapo-transpiration leading to soil moisture deficit. However, Chandrashekar (1994) has reported that Cr is an important parameter as a system variable and the soil moisture as a driving force. In the present study neither T_{min} nor VP showed any significant relation with Cr.

Regression analysis

The regression equation of different clones for the two locations together with values of R^2 are presented in Table 3, 4 and 5. Variation in P can be explained to the extend of 9 to 86 per cent depending on the clone and the location. However, the combined analysis of P showed 48 percentage of explained variance. Clone PR 107 and PB 235 were explained by only 5 and 8 percentage of P respectively in dry sub-humid climate, whereas all clones explained above 34 per cent in the humid location. F can be explained to the extent of 61 per cent on combined analysis with a variation up to 68 per cent depending on the clone and the location. A wide variation in Cr was observed in the dry sub-humid location and clone RRIM 600 explained 44 per cent variation. Most of the clones were on par in the humid region. Cr may be controlled by a number of other factors which in general explains only up to 9 per cent in this study.

Climatic parameters influence yield through the yield components. A general equation may be more appropriate taking into consideration all the clones and both the locations. The equations derived for each yield component based on the present observations are as follows :

Flow rate = $0.115 - 0.003\ T_{max} - 0.001\ T_{min} + 0.03\ VP$

Plugging index = $-10.8 + 0.35\ T_{max} + 0.135\ T_{min}$

Dry rubber content = $18.1 + 0.35\ T_{max}$

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