Indian Journal of Natural Rubber Research, 9(1) : 12-16, 1996

YIELD AND ANATOMICAL CHARACTERS IN *HEVEA* : A PATH COEFFICIENT ANALYSIS AND CHARACTERISATION OF CLONES

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Premakumari, D., Panikkar, A.O.N., Marattukalam, J.G. and Sethuraj, M.R. (1996). Yield and anatomical characters in *Hevea* : A path coefficient analysis and characterisation of clones. *Indian Journal of Natural Rubber Research*, 9(1) : 12-16.

Ten clones of *Hevea brasiliensis* were characterised for early yield, girth and bark anatomical traits. Genotypic correlations and direct/indirect effects of girth and structural traits with yield were estimated.

Laticifer area index at the year of opening was the most reliable parameter for early prediction of yield which showed the highest positive correlation ($r = 0.691$; $P<0.01$) and highest positive direct effect (1.832) on yield over the subsequent three years. The intensity of laticifer anastamosing and ray width also directly contributed to yield and were observed to be independent characters. The number of latex vessel rows showed significant positive correlation with yield ($r = 0.589$; $P<0.01$) but its direct effect was negative. Correlation of girth, latex vessel density and latex vessel diameter with yield were not significant. These traits and the number of latex vessel rows contributed to yield via laticifer area index.

Key words : *Hevea*, Bark anatomy, Latex vessels, Yield.

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INTRODUCTION

Secondary laticifers of *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell. Arg. distributed in the bark of the trunk are commercially exploited for latex which yields natural rubber. A wide gap exists between the achieved yield of 2500-3000 kg/ha/year and the potential yield of 9000 kg/ha (Templeton, 1969). An attempt was made to estimate genotypic correlations of bark anatomical characters and girth at the time of opening of trees for exploitation, with subsequent yield over three years to utilise these parameters in selection.

MATERIALS AND METHODS

The study was conducted in ten rubber clones (RRIC 7, RRIC 36, RRIC 45, RRIC 52, RRIC 100, RRIC 102, RRIC 104, RRIC 105, Nab 17 and GT 1) laid out in a randomized block design with three replications and planted in 1976 at the Central Experiment Station of the Rubber Research Institute of India. The trees were opened for tapping in 1983 and exploited under 1/2 S d/2 6d/7 system. Girth was measured and bark samples collected from a height of 150 cm above the bud union in 1983 and fixed in F.A.A. Samples were sectioned in radial (100 µm thickness) and tangential (80 µm) planes and sections stained with Sudan III. Number of latex vessel rows, density of latex vessels (expressed as numbers per cm per unit girth per row), diameter of latex vessel (µm), laticifer anastamosing (expressed as the number of connections between latex vessels per 0.25 mm height), laticifer area index as cross sectional area of functional laticifers in a halfspiral cut (Gomez *et al.*, 1972), height of phloem rays (μm) and width of phloem rays (μm) were recorded.

Yield was recorded at fortnightly intervals by cup coagulation method for three consecutive years from opening. Clone-wise annual mean and yield/plot over the three years was computed.

For comparing the varietal means with grand mean of clones CD was computed using the formula SE = n-1/n MSE/r where 'n' is the number of clones. For each character the clones were rated as high, medium and low in comparison to the grand mean. Genotypic correlations were computed using plot means. For variance and co-variance analysis, estimation of genotypic correlations and path coefficient analysis (Singh and Choudhary, 1976) were followed.

RESULTS

Yield, girth and all structural traits were found to be highly significant clonal characters (Table 1). The clones varied widely for the combination of characters. Three clones, RRIC 100, RRIC 102 and RRIC 36 recorded high yield. In the high yielders, laticifer area index was combined with high intensity of laticifer anastamosing.

Genotypic correlations among yield, girth and structural characters are shown in Table 2. Yield showed highly significant positive correlations with laticifer area index and total number of latex vessel rows. The relationship of other characters studied with yield was not significant. Girth showed significant positive correlation with latex vessel diameter, ray width and negative correlation with latex vessel density. Laticifer area index had positive correlation with latex vessel diameter and number of

Table 1. **Characterisation of ten *Hevea* clones for girth and anatomical characters at opening and mean yield over subsequent three years**

Clones	Laticifer area index	No. of latex vessel rows	Density of latex vessels	Diameter of latex vessels (μm)	Intensity of anastamosing	Ray height (μm)	Ray width (μm)	Girth (cm)	Yield g/tree/tap
RRIC 45	12.02^{L}	9.12^{L}	328.00	16.73	7.17	365.64	43.91^{L}	61.69	46.05
RRIC 100	22.44^{H}	11.43	337.33^{H}	18.72^{H}	8.23^{H}	370.17	40.36^{L}	69.28	64.21^{H}
RRIC 7	17.27	12.06	298.27^{L}	17.88	7.27	429.23^{H}	48.69	62.64^{L}	49.03
RRIC 104	20.92^{H}	11.35	293.33^{L}	18.42	6.01^{L}	398.51	53.38^{H}	78.54^{H}	45.52
RRIC 105	11.59^{L}	7.85^{L}	329.87	16.53^{L}	7.04	302.54^{L}	48.45	70.31	39.49^{L}
RRIC 52	12.92^{L}	6.45^{L}	298.07^{L}	19.59^{H}	7.52	346.50	42.29^{L}	74.30^{H}	33.97^{L}
RRIC 36	20.74^{H}	14.35^{H}	312.00	17.94	7.56^{H}	389.88	49.78^{H}	63.36	54.55^{H}
GT 1	11.84^{L}	10.56	334.07^{H}	15.15^{L}	7.41	479.23^{H}	41.48^{L}	62.17^{L}	37.97^{L}
Nab 17	21.51^{H}	13.98^{H}	314.00	18.09	6.24^{L}	370.26	41.05^{L}	62.64^{L}	46.17
RRIC 102	16.55	12.02	324.40	16.62	6.88	378.97	48.25	65.20	54.09^{H}
SE	1.84	0.73	7.14	0.?	0.22	10.96	1.16	2.67	4.84
CD	5.46	2.17	21.20	1.49	0.65	32.57	3.45	6.00	10.01
Grand mean	16.78	10.92	316.93	17.57	7.13	389.09	46.77	67.02	47.10
*CD interation	2.06	1.44	14.30	1.00	0.42	21.84	2.32	3.76	6.76

*CD for grand mean Vs clone at P = 0.05; H - High; L - Low

Table 2. **Genotypic correlations of girth and bark anatomical characters at opening with mean yield over subsequent three years**

Character	Girth	Laticifer area index	Latex vessel diameter	Latex vessel density	Intensity of anasta-mosing	Latex vessel rows	Ray height	Ray width
Yield	-0.034	0.691**	0.203	0.181	0.302	0.589**	0.053	-0.254
Girth		0.271	0.499**	-0.392*	-0.171	-0.276	-0.271	0.491**
Laticifer area index			0.568**	-0.269	-0.015	0.752**	0.061	-0.001
Latex vessel diameter				-0.603**	0.100	0.033	-0.227	0.352
Latex vessel density					0.343	-0.123	-0.044	-0.725**
Intensity of anastamosing						-0.110	-0.023	-0.238
Latex vessel rows							0.296	-0.130
Ray height								-0.199

* $P < 0.05$ ** $P < 0.01$

latex vessel rows and indicated a negative relationship with latex vessel density. Latex vessel density showed highly significant negative correlation with ray width.

The direct and indirect effects of girth and bark anatomical characters on yield are shown in Table 3. Among the eight characters the highest positive direct effect on yield was for laticifer area index (1.833) followed by intensity of anastamosing (0.252) and width of phloem rays (0.175). Girth showed high magnitudes of positive effects *via* laticifer area index (0.497) and number of latex vessel rows (0.230) which was nullified by its negative direct effect and indirect effect via diameter and density of latex vessels and intensity of anastamosing. Number of latex vessel rows (1.378) and diameter of latex vessels (1.040) had high magnitudes of indirect effect on yield via laticifer area index.

DISCUSSION

The concept of path coefficients suggested by Wright (1921) and elaborated by Dewey and Lu (1959) has not been well exploited in *Hevea brasiliensis*. Laticifer area index represents the total quantity of functional laticifers in terms of cross sectional area in a half spiral cut. Although it was proposed by Gomez *et al.* (1972), they could not establish any significant relationship of this index with yield.

Girth, number of latex vessel rows and the density and diameter of latex vessels are factors of laticifer area index. The highest degree of correlation and magnitude of direct effect on subsequent yield was for laticifer area index. Of its component traits, only the number of latex vessel rows showed significant positive correlation with yield, with negative direct effect of considerable magnitude. Latex vessel diameter and girth also had negative direct effect on yield. These relationships of the component traits with yield and the negative associations of girth with the number of latex vessel rows and density of latex vessels indicate the possibility that high partitioning of substrates for growth is detrimental to latex production.

Simple correlation among yield, girth and structural traits such as bark thickness,

Table 3. **Direct and indirect effect of girth and bark anatomical characters at opening on mean yield over subsequent three years**

Character	Girth	Laticifer area index	Diameter of latex vessels	Density of latex vessels	Intensity of anastamosing	No. of latex vessel rows	Ray height	Ray width	Genotypic correlations
Girth	<u>-0.481</u>	0.497	0.325	-0.011	-0.043	0.230	0.014	0.086	-0.034
Laticifer area index	-0.130	<u>1.832</u>	-0.370	-0.007	-0.004	-0.625	-0.003	0.000	0.691**
Diameter of latex vessels	-0.240	-1.040	<u>-0.652</u>	-0.017	0.025	-0.027	0.011	0.062	0.203
Density of latex vessels	0.189	-0.492	0.393	<u>0.028</u>	0.087	0.102	0.002	-0.127	0.181
Intensity of anastamosing	0.082	-0.028	-0.065	0.010	<u>0.252</u>	0.092	0.001	-0.042	0.302
Latex vessel rows	0.133	1.378	-0.021	-0.003	-0.028	<u>-0.831</u>	-0.015	-0.023	0.589**
Height of phloem rays	0.130	0.112	0.148	-0.001	-0.006	-0.246	<u>-0.050</u>	-0.035	0.053
Width of phloem rays	-0.236	-0.001	-0.230	-0.020	-0.599	0.108	1.010	<u>0.175</u>	-0.254

Residual effect = 0.5534

number of latex vessel rows and diameter of latex vessels have been reported earlier (Ho *et al.*, 1973; Narayanan *et al.*, 1973; 1974; Ho, 1976; Premakumari and Panikkar, 1989). These traits as single factors could not be proved as effective parameters for yield owing to the mutual interference and unfavourable associations (Wycherley, 1969; Ho, 1972). Swaminathan (1975) emphasised the need for a complementing balanced system as more effective parameter for yield prediction. Laticifer area index is such a complementing system.

The height and width of phloem rays which influence the orientation of latex vessels (Premakumari *et al.*, 1988) showed positive direct effect on yield. Intensity of anastamosing which has a positive trend of association with yield is independent of laticifer area index and hence is an additional parameter for yield prediction.

The ten clones varied much for the combination of different structural traits, yield and girth while the two major yield components, laticifer area index and intensity of laticifer anastamosing have been combined in all the three high yielders. The characters considered in this study at the time of opening for tapping contributed to 69 per cent of the yield over the three subsequent years.

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