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GENETIC VARIABILITY AND ASSOCIATIONS AMONG YIELD AND CERTAIN YIELD COMPONENTS IN FORTY CLONES OF *HEVEA BRASILIENSIS*

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ABSTRACT

Forty clones of rubber were evaluated for the extent of variability for yield and certain yield components at the fourth year of tapping. Highly significant clonal variation was evident for all the traits studied enabling the identification of clones superior for each yield component. Genotypic correlations with volume of latex, dry rubber content, latex flow rate, girth, girth increment and bark thickness and negatively correlated with plugging index and yield depression under stress. Employing the discriminant function technique, eleven clones with high selection indices were identified as potential parents for future breeding programmes.

INTRODUCTION

Genetic variability in the base population is the most essential prerequisite to the success of crop improvement through selection. Rubber (*Hevea brasiliensis* Wild. ex Adr. de Juss. Muell. Arg.) is a predominantly cross pollinated species which is propagated widely through vegetative means. As such, hybridization followed by clonal selection is the most important method of genetic improvement in the species. A number of improved clones have been evolved over the years in India and other rubber growing countries. Exotic clones are introduced to India through clone exchange programmes and these are subjected to preliminary evaluation trials with the popular indigenous clone as control.

The present study is an assessment of the genetic variability for yield and certain yield components in forty clones of Indian, Indonesian, Malaysian and Sri Lankan origin. An attempt has been made to employ the discriminant function technique to identify clones possessing superiority for the economic attributes studied.

MATERIALS AND METHODS

The study was carried out on forty clones planted in a randomized block design with three replications and five trees per plot. Observations on ten variables were recorded at the fourth year of tapping. Dry rubber yield, yield depression under stress, volume of latex, dry rubber content (DRC), rate of latex flow and plugging index were recorded at monthly intervals over a period of one year and the annual mean values were computed. Yield during the stress period from February to May was recorded and depression in yield under stress was computed as percentage over the annual mean value. Dry rubber content was determined as percentage on a dry weight by volume basis. Plugging index was computed following Milford *et. al.* (1969). Girth, girth increment during the year, virgin bark thickness and renewed bark thickness were the other traits studied.

Following the analysis of variance (Kavitha *et al.* 1992), the data were subjected to an assessment of the genotypic correlations among the attributes studied. For computation of a selection index to identify superior clones, a multivariate approach namely discriminant

Table I. Variability for yield in clones

Sl. No.	Clone	Dry rubber yield (g/tree / tapping)	Yield depression under stress (%)	Volume of latex (ml / tree / tapping)	Sl. No.	Clone	Dry rubber yield (g/tree / tapping)	Yield depression under stress (%)	Volume of latex (ml / tree / tapping)
1	Waring 4	27.06	32.4	93.72	21	PB 86	48.16	17.6	160.43
2	AVROS 352	33.98	27.6	137.26	22	GT 1	54.14	37.4	175.47
3	Ch 4	27.16	35.1	88.59	23	Ch 153	52.95	30.2	159.06
4	PB 213	39.95	34.2	136.59	24	Ch 29	22.37	48.8	77.33
5	BD 10	27.00	33.6	85.00	25	AVT 73	43.26	13.8	145.68
6	PB 215	54.67	29.9	158.52	26	PB 5/139	40.16	37.0	116.72
7	PR 107	36.60	30.7	112.90	27	PB 6/50	45.46	31.4	155.51
8	Mil 3/2	39.40	19.1	136.21	28	Ch 26	66.64	28.7	199.26
9	Gl 1	46.03	27.3	144.93	29	RRII 105	68.20	23.4	198.16
10	P B 28/83	67.13	19.5	209.88	30	PB 5/51	56.05	35.5	151.60
11	PB 28/83	63.36	18.1	172.58	31	PB 5/60	38.21	34.9	114.06
12	Ch 32	31.76	25.2	102.25	32	PB 5/76	63.65	34.3	175.20
13	Lun N	36.54	22.4	117.64	33	RSY 23	40.58	25.1	121.24
14	Tjir 16	28.51	49.4	105.69	34	Ch 2	46.87	45.6	148.01
15	PB 230	57.77	37.3	173.82	35	BD 5	29.94	42.2	85.88
16	PB 28/59	35.20	39.2	117.97	36	HC 28	41.95	18.4	125.54
17	HC 55	31.58	23.3	98.73	37	PB 217	71.19	16.9	207.34
18	LCB 1320	57.68	35.7	171.68	38	PB 5/63	53.51	29.0	163.49
19	PB 206	47.01	30.0	150.85	39	AVROS 25	37.10	39.3	121.49
20	PB 242	62.94	22.1	187.53	40	PB 235	77.01	25.0	212.39
General Mean							46.22	30.11	142.90
Variance Ratio							3.71**	2.21**	2.73**
C. D. (0.05)							20.740	16.346	63.611

** Significant at P= 0.01

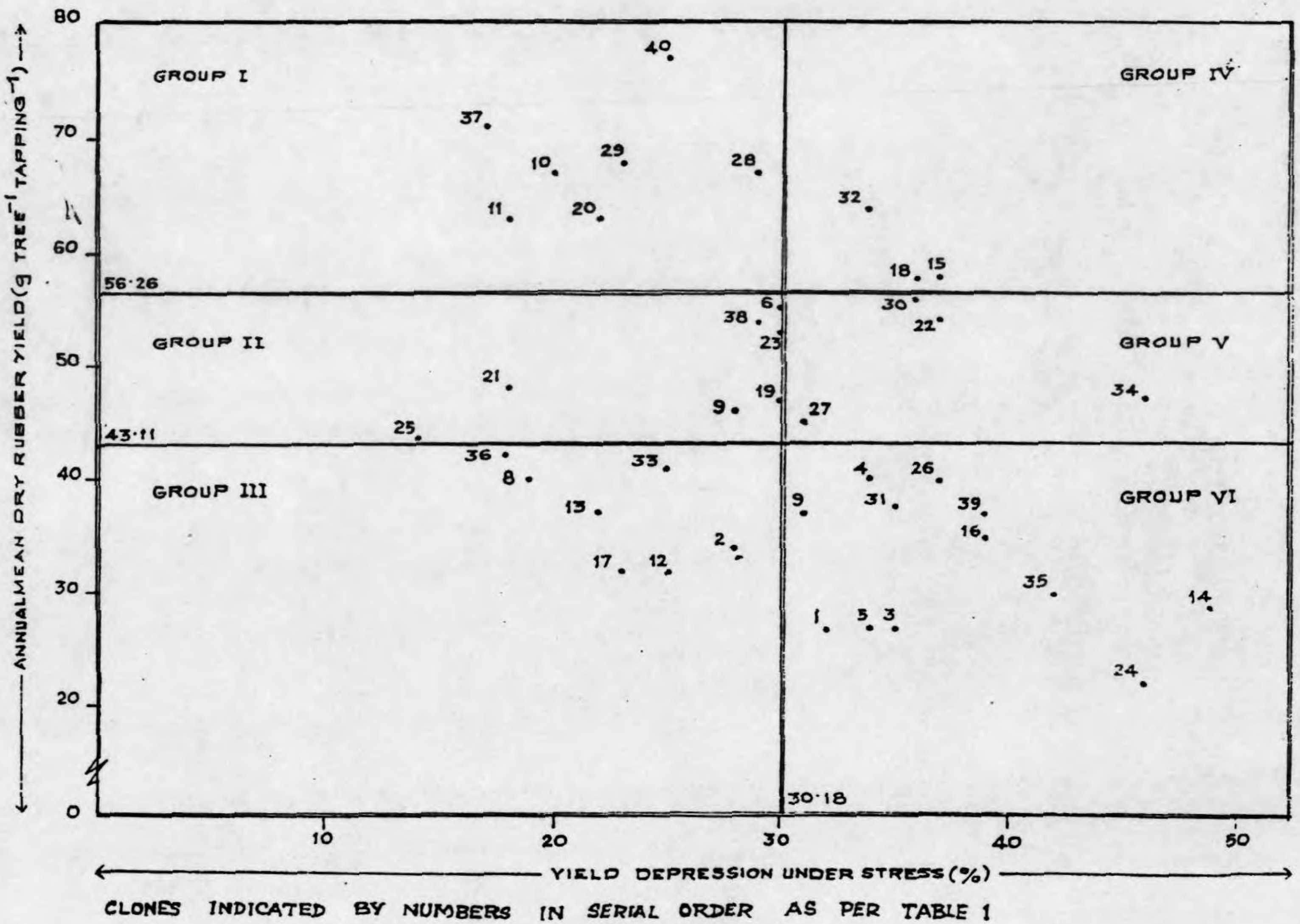

Fig. 1. Dry rubber yield against yield depression under stress in clones

Table II. Physiological components of yield in clones

Sl. No.	Clone	D.R.C (%)	Rate of latex flow (ml/minute)	Plugging Index	Sl. No.	Clone	D.R.C (%)	Rate of latex flow (ml/minute)	Plugging Index
1	Waring 4	28.13	2.63	4.30	21	PB 86	30.50	5.60	3.85
2	AVROS 352	33.58	3.85	4.35	22	GT 1	33.92	4.09	3.19
3	Ch 4	32.62	3.34	5.41	23	Ch 153	37.63	5.43	5.52
4	PB 213	33.31	4.35	4.31	24	Ch 29	30.16	2.72	4.64
5	BD 10	38.36	3.10	5.39	25	AVT 73	29.40	4.08	3.67
6	PB 215	37.66	5.74	5.07	26	PB 5/139	35.28	3.75	4.54
7	PR 107	37.08	4.38	4.82	27	PB 6/50	32.17	4.70	3.65
8	Mil 3/2	33.01	3.76	2.90	28	Ch 26	31.89	5.83	3.34
9	Gl 1	35.25	5.11	4.82	29	RRII 105	37.63	6.73	4.25
10	P B 252	34.52	6.51	3.45	30	PB 5/51	39.96	5.34	4.55
11	PB 28/83	40.88	5.02	3.24	31	PB 5/60	33.78	4.38	5.26
12	Ch 32	32.26	3.07	3.92	32	PB 5/76	40.82	6.33	4.73
13	Lun N	34.57	3.81	4.45	33	RSY 23	37.91	5.53	5.55
14	Tjir 16	30.13	3.50	5.24	34	Ch 2	34.99	5.42	6.21
15	PB 230	36.87	5.55	4.42	35	BD 5	36.99	4.01	7.29
16	PB 28/59	31.84	2.87	3.01	36	HC 28	33.86	4.56	4.65
17	HC 55	37.80	3.12	4.99	37	PB 217	36.48	7.31	4.05
18	LCB 1320	38.76	5.23	3.90	38	PB 5/63	32.65	4.56	3.27
19	PB 206	33.30	4.52	3.82	39	AVROS 255	32.40	3.90	4.13
20	PB 242	35.19	6.18	3.69	40	PB 235	38.21	6.15	3.15
General Mean							34.77	4.65	4.37
Variance Ratio							7.32	4.06	3.22
C. D. (0.05)							3.312	1.673	1.463

** Significant at P = 0.01

Table III. Girth and bark thickness in clones

Sl. No.	Clone	Girth (cm)	Girth increment (cm / year)	Virgin bark thickness (mm)	Renewedbark thickness (mm)	Sl. No.	Clone	Girth (cm)	Girth increment (cm/year)	Virgin bark thickness (mm)	Renewed bark thickness (mm)
1	Waring 4	65.08	2.92	6.08	5.50	21	PB 86	73.25	4.04	6.58	6.33
2	AVROS 352	75.50	4.08	8.00	7.67	22	GT 1	77.25	4.09	7.42	7.00
3	Ch 4	68.00	2.63	7.67	6.33	23	Ch 153	75.58	4.30	7.75	7.83
4	PB 213	66.92	2.92	7.50	7.00	24	Ch 29	67.67	3.33	6.17	6.33
5	BD 10	72.25	3.79	7.00	6.83	25	AVT 73	86.42	5.96	7.00	7.50
6	PB 215	86.92	4.67	8.58	8.00	26	PB 5/139	65.50	3.25	6.92	6.83
7	PR 107	63.83	3.38	7.33	6.67	27	PB 6/50	79.67	4.50	7.50	7.17
8	Mil 3/2	74.83	3.88	6.75	7.00	28	Ch 26	74.25	3.79	7.58	7.50
9	Gl 1	72.08	4.21	8.58	8.00	29	RRII 105	68.75	3.04	7.58	7.50
10	P B 252	80.25	3.92	9.33	8.50	30	PB 5/51	71.75	4.34	8.33	6.33
11	PB 28/83	62.92	3.42	8.33	7.33	31	PB 5/60	68.33	2.75	6.17	6.17
12	Ch 32	60.08	2.34	5.75	6.33	32	PB 5/76	73.25	4.00	7.17	7.17
13	Lun N	65.75	2.46	7.67	6.67	33	RSY 23	78.25	5.58	7.08	7.50
14	Tjir 16	65.67	2.71	7.50	8.00	34	Ch 2	75.08	4.75	7.67	7.00
15	PB 230	75.67	4.42	7.08	7.00	35	BD 5	65.33	3.38	6.08	7.83
16	PB 28/59	72.00	4.83	7.00	7.67	36	HC 28	76.50	4.79	7.42	6.67
17	HC 55	67.17	2.71	6.50	6.67	37	PB 217	85.08	4.50	7.25	6.67
18	LCB 1320	80.83	4.30	7.75	7.50	38	PB 5/63	68.33	3.54	8.00	7.00
19	PB 206	64.75	2.59	5.75	6.33	39	AVROS 255	69.50	2.46	6.50	6.17
20	PB 242	78.92	3.71	9.25	8.67	40	PB 235	96.33	4.96	9.17	7.83
	General Mean							72.89	3.78	7.37	7.10
	Variance Ratio							7.32	4.06	2.96**	2.70**
	C.D (0.05)							3.312	1.673	1.477	1.950

** Significant at P=0.01

Table IV. Genotypic correlations among yield and yield components

Parameters	Dry rubber yield	Yield depression under stress	Volume of latex	D.R.C.	Rate of flow	P.I.	Girth	Girth increment	Virgin bark thickness	Renewed bark thickness
Dry rubber yield	-	-0.43	0.98	0.46	0.92	-0.38	0.57	0.37	0.64	0.38
Yield depression under stress	0.320	-	-0.42	-0.11	-0.45	0.48	-0.31	-0.33	-0.17	-0.01
Volume of latex	0.012	0.356	-	0.33	0.91	-0.46	0.59	0.45	0.71	0.50
D.R.C	0.180	0.342	0.260	-	0.52	0.33	0.13	0.18	0.40	0.26
Rate of flow	0.029	0.321	0.050	0.167	-	-0.05	0.54	0.44	0.64	0.45
Plugging Index	0.265	0.314	0.258	0.266	0.332	-	-0.18	-0.07	-0.20	0.08
Girth	0.181	0.348	0.184	0.257	0.178	0.320	-	1.00	0.55	0.55
Girth increment	0.310	0.460	0.340	0.313	0.284	0.419	0.228	-	0.55	0.51
Virgin bark thickness	0.174	0.416	0.288	0.232	0.191	0.350	0.210	0.351	-	0.84
Renewed bark thickness	0.272	0.468	0.012	0.278	0.256	0.408	0.244	0.325	0.916	-

Values above the diagonal are the genotypic correlation co-efficients
Values below the diagonal are the S.E. values of genotypic correlation coefficients.

Table V. Ranking of clones based on Selection Index

Rank	Clone	Selection Index	Rank	Clone	Selection Index
1.	PB 235	621.303	21	PB 213	435.143
2.	PB 217	599.141	22	HC 28	433.027
3.	PB 252	583.814	23	PR 107	432.570
4.	PB 242	573.018	24	AVROS 352	430.616
5.	PB 5/76	557.788	25	AVROS 255	420.664
6.	RRII 105	556.531	26	PB 5/60	414.548
7.	PB 215	545.907	27	PB 206	414.023
8.	PB 5/51	535.852	28	PB 5/139	404.882
9.	Ch 26	526.375	29	AVT 73	402.558
10.	LCB 1320	526.078	30	Mil 3/2	399.545
11.	PB 230	510.932	31	Lun N	396.265
12.	PB 28/83	492.603	32	Tjir 16	386.966
13.	Ch 2	487.742	33	Ch 4	381.867
14.	Gl 1	481.189	34	Ch 29	379.202
15.	Ch 153	480.474	35	PB 28/59	379.010
16.	RSY 23	480.312	36	BD 10	364.664
17.	PB 6/50	471.008	37	BD 5	355.035
18.	PB 86	469.154	38	HC 55	336.842
19.	PB 5/63	467.332	39	Ch 32	325.075
20.	GT 1	451.129	40	Waring 4	314.396

function (Smith, 1937) was employed including the observed characters based on their genetic worth. The selection index (I) = $b_1x_1 + b_2x_2 +$ .... $b_{10}x_{10}$ where x_1, x_2, ...x_{10} represent the mean values for the traits and b_1, b_2 .... b_{10}.... are the weighing coefficients calculated based on the genotypic and phenotypic variances and covariances (Dabholkar, 1992).

RESULTS AND DISCUSSION

The performance of the forty clones in respect of yield and yield attributes is presented in Tables I to III. Highly significant clonal variation was observed for all the ten attributes. The mean dry rubber yield ranged from 22.37 g per tree per tapping to 77 g per tree per tapping with ten clones exhibiting superiority for the trait. Yield depression under stress ranged from 13.84 per cent to 49.4 per cent with a general mean of 30.11 per cent.

Figure 1 shows the annual mean yield plotted against the extent of yield depression under stress for the forty clones studied. Seven clones viz., PB 235, PB 217, RRII 105, Ch 26, PB 242, PB 28/83 and PB 252 were classified under group I representing high yield in combination with a low yield depression under stress. The summer months, i.e., the period from February to May are lean in terms of rubber yield irrespective of clones (Ninane, 1970; Sethuraj, 1977). A distinct clonal variation is observed in the variation in yield of clones in response to seasonal changes. In certain clones like Tjir 1 which is a typical example of a drought susceptible clone, yield depression in summer is more pronounced (Sethuraj, 1992). Maintenance of high yield levels under stress is one attribute which determines the yielding ability of a clone. Therefore, the clones classified under group I could be considered to pessess stability for yield and hold promise for further testing in areas prone to stresses such as drought. The second category comprised seven clones viz., PB 215, PB 5/63, Ch 153, PB 86, PB 206, GI 1 and AVT 73 which showed medium yield coupled with low yield depression under stress. Three clones, PB 5/76, LCB 1320 and PB 230 were classified as high yielders but they showed a high yield depression under stress.

A wide range of variation was recorded for most of the yield components studied. Volume of latex ranged from 77.33 to 212.33 ml per tree per tapping and DRG ranged from 28.13 to 40.88 per cent. Initial flow rate ranged from 2.63 to 7.31 ml per minute and plugging index ranged from 2.90 to 7.29. Girth ranged from 60.08 to 96.33 cm while girth increment ranged from 2.34 to 5.96 cm per year. Mean values of both virgin and four year's renewed bark thickness ranged from about 5.5 to 9.0 mm. Superiority for the various yield components was found scattered in different clones which gave medium to high yields. This necessitated formulation of an index to determine the overall superiority of each clone for the important yield components.

The genotypic correlations among the traits studied, along with the respective SE values are shown in Table IV. The correlation values ranged from 0.01 to 0.98 while the SE values ranged from 0.012 to 0.468. Rubber yield showed the highest positive correlation with volume of latex (r = 0.98, S.E. = 0.012) followed by rate of latex flow (r =0.92, S.E.= 0.29). The high correlations accompanied by low SE values indicate the consistent relationship of these traits with dry rubber yield. Virgin bark thickness, girth and DRC are the other traits which showed negative correlation with yield accompanied by moderate values of S.E. Girth increment rate, however, had only a low correlation with rubber yield. Girth and girth increment rate exhibited fairly good correlation (r = 0.55) with bark thickness. The present results are in conformity with earlier reports (Sethuraj *et.*

al., 1974; Tan *et. al.*, 1975 and Simmonds, 1989) and lend further support to the view that volume of latex, DRC, rate of latex flow, girth, girth increment rate and bark thickness are components having a positive genetic association with rubber yield while the extent of yield depression under stress and plugging index have a negative relationship wit rubber yield.

The correlation estimates indicate the extent of influence of various components on rubber yield. Assigning weights to those characters based on their genetic worth, the discriminant function technique enabled the formulation of selection indices for the forty clones. This multivariate approach enabled ranking of the clones based on their indices. The indices ranged from 314.40 (Waring-4) to 621.30 (PB 235) as shown in Table V. Eleven clones viz., PB 235, PB 217, PB 252, PB 242, PB 5/76, RRII 105, PB 215, PB 5/51, Ch 26, LCB 1320 and PB 230 exhibited indices greater than 500. This reflects the superiority of these clones with respect to yield and important yield contributing characters. A previous study on the same set of clones enabled grouping them into 8 genetically divergent clusters (Kavitha *et. al.*, 1992). The eleven superior clones identified in this study were located in three different clusters. Seedling progeny analysis of these clones (Kavitha, 1992) revealed PB 217, PB 252, PB 242, RRII 105, PB 215, PB 5/51 and Ch 26 to be likely prepotents.

Rubber yield in *Hevea brasiliensis* is a manifestation of various morphological, anatomical, physiological and biochemical characters of the tree. As such, superiority of parent clones for various yield components rather than yield *per se* is vital to the success of breeding programmes. Crosses between genetically divergent parents are known to help in a better realization of heterosis in the F_1 while prepotency in these parents ensures the transmission of their superior characters to the progeny.

It could be concluded that clones RRII 105, PB 217, PB 252, PB 242, PB 215, Ch 26 and PB 5/51 which were prepotent as well as superior in terms of yield and yield components as reflected by their high selection indices could be incorporated as parents in hybridization programmes in cross combinations based on their specific traits of superiority and their genetic distances from one another.

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