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PRELIMINARY OBSERVATIONS OF THE 1981 IRRDB *HEVEA* GERMPLASM. II VARIABILITY, DRY MATTER AND MORPHOLOGICAL CHARACTERS

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ABSTRACT

Seventy two genotypes were selected from the wild population of *Hevea brasiliensis* of 1981 IRRDB exploration for assessing the nature and extent of variability present, the degree of association among characters and their direct and indirect effect on juvenile yield. The population mean for most of the characters studied were lower than that of the control, except for the characters, number of leaves in the third, whorl, LAR and leaf shoot ratio indicating the vigorous growth habit of these wild genotypes. Individual genotypes exhibited wide variation for most of the characters studied. Positive genotypic correlation was noted between juvenile yield with height, number of whorls, girth, LAI, total leaf weight, aerial biomass and leaf weight per unit leaf area. Very high positive genotypic correlation was exhibited by LAI with total leaf weight and aerial biomass. Path analysis indicated the importance of total leaf weight on juvenile yield.

INTRODUCTION

The success of any crop improvement programme requires availability of diverse germplasm and therefore, scientific evaluation of variability collected through explorations or procured from other sources assumes importance. The expedition organized by the IRRDB in 1981 for *Hevea brasiliensis* was important in this connection which helped to collect a wide range of genetically diverse materials from the three different agroclimatic zones in the three states of Acre, Rondonia and Matto Grosso in Brazil.

The narrow genetic base resulting from unidirectional selection over the years for yield, and the absence of suitable varieties adapted to non-traditional rubber growing areas have necessitated a detailed study of wild genotypes from this IRRDB collection. In this connection a preliminary study was conducted with the objective of assessing the nature and extent of variability present in the wild population, the degree of association among characters and their direct and indirect effects on juvenile yield, giving more importance to aerial biomass (dry matter accumulation) and other related physiological parameters.

MATERIALS AND METHODS

Seventy two genotypes of the Brazilian germplasm planted during 1989 at the Central Experimental Station of the Rubber Research Institute of India, Kottayam were selected for the study along with the control RRII 105. These genotypes were representatives from the three states of Brazil - Acre, Rondonia and Matto Grosso. The plants were planted in 1 x 1m spacing and five trees per genotype were selected at the age of 18 months for recording the following observations: total height of the plant from bud union (cm), total number of whorls per genotype, total number of leaves in third whorl per genotype, girth of plant at 20 cm height above the bud union (cm), leaf area index (LAI) of each genotype, total dry weight of the leaves per genotype (g), dry matter accumulation (aerial biomass) of each genotype (g), test tap yield (average of two seasons) by incision method (g), Leaf Area Ratio (LAR), leaf weight per unit leaf area, and leaf shoot ratio for each genotype.

Leaf area was measured using portable Leaf Area Meter and test taping was conducted by incision method proposed by Annamma *et al.* (1989).

Mean values, estimates of variability like

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phenotypic and genotypic coefficients of variation (PCV and GCV respectively) and the genetic parameters - broad sense heritability (H^2) and genetic advance (GA) were calculated. Genotypic and phenotypic coefficients of variation, correlation and path analysis were worked out following Singh and Choudhary (1985), and heritability in the broad sense was determined as per Allard (1960).

Since the plants within a genotype were not grown randomly over the environment, the variation among the genotypes with respect to the characters studied were not tested for their significance.

RESULTS AND DISCUSSION

A wide variation was observed among the wild genotypes for the characters studied (Table I). Except for the characters like number of leaves in third flush, leaf area ratio (LAR) and leaf shoot ratio, the mean performance of wild genotypes was poor compared to the control. The superiority of wild genotypes for the above characters shows their vigourous growth habit. As a result of this, the total leaf area of wild genotypes will be more compared to the control RRII 105. Leaf area is the major determinant of crop yield, and in the seedling stage much of the assimilatory surface is contributed primarily by the leaf area (Sinha and Khanna, 1975). The assimilatory capacity of a leaf whorl may reflect the differences in assimilatory capacity of canopies in mature plants. (Nugawela and Aluthhewage, 1985). The test tap yield as the average of the two seasons was found to be only one third that of the corresponding yield for the control.

A wide range of variation was exhibited by the individual genotypes in the population for all the characters studied. The genotype MT 1650 exhibited the maximum values for the characters total height of the plant and also the test tap yield, while the genotypes AC 2040 and RO 1243 have the least values for these characters respectively. Maximum values for the girth and dry matter accumulation (aerial biomass) in the wild genotypes were exhibited by R O 1269 while the genotypes MT 1655 and AC 2040 had the minimum girth and dry matter accumulation respectively. Maximum number of flushes and number of leaves in the 3rd flush were seen in the genotypes from the state of Rondonia - RO 1324 and RO 1334 respectively, while the minimum values for these characters were in the Acre genotypes. AC 2016 had the maximum LAI and also the highest total leaf weight, while RO 1348 exhibited the lowest values for these two characters. In the case of LAR and leaf shoot ratio the genotype AC 2124 showed the maximum performance where as the genotypes RO 1558 and RO 1334 were the poor performers respectively. Leaf weight per unit leaf area do not show any variation either among the wild genotypes or between wild genotypes and the control, indicating the uniformity in the leaf thickness of these genotypes. While considering the maximum values obtained for the wild genotypes, there is a two-fold increase in the values compared to the control, except for girth and test tap yield. This shows the general vigour of the wild genotypes compared to the control, ultimately leading to a high value for total aerial biomass. The rubber production of a tree depends upon the total annual biomass increment. *Hevea* trees when tapped exhibit a depression of girth increment

Table I. Range of variation among genotypes for the characters studied

Traits	Wild genotypes				General Mean	Control (RRII 105) Mean
	Maximum		Minimum			
Total height (cm)	411	(MT 1650)	171	(AC 2040)	276.9	289.6
Total number of flushes	21	(RO 1324)	4	(AC 2124)	11.2	13.6
No. of leaves in 3rd flush	18	(RO 1334)	6	(AC 2057)	11.0	9.6
Girth (cm)	16	(RO 1269)	8	(MT 1655)	11.4	12.1
LAI	4.3	(AC 2016)	0.59	(RO 1348)	2.2	2.6
Total leaf wt. (8)	444.6	(AC 2016)	63.2	(RO 1348)	215.2	275.4
Aerial biomass (g)	2415.1	(RO 1269)	393.5	(AC 2040)	1106.5	1479.3
Test tap yield (g)	0.26	(MT 1650)	0.08	(RO 1243)	0.2	0.6
LAR	42.41	(AC 2124)	9.05	(RO 1558)	20.76	17.62
Leaf wt/unit leaf area	0.012		0.008		0.01	0.011
Leaf shoot ratio	0.594	(AC 2124	0.107	(RO 1334)	0.262	0.229

and canopy growth. Hence a high gorwth rate is required to maintain the growth whilst giving a high yield (Nugawela and Althhewage, 1986). High correlation between total aerial dry weight and photosynthetic rate were also reported earlier (Anonymous, 1987). Again, the high value for total number of whorls in the wild genotype indicates the possibility of more number of latex vessel rings in the stem.

A provenance wise comparison of the performance of wild genotypes for the different characters studied is given in Table II. The wild genotypes from the provenenance of Rondonia showed a better average performance for the characters number of leaves in the third flush, girth and total dry matter content. But for the characters total height, total number of flushes, LAI, total leaf weight, LAR and leaf shoot ratio the genotypes from the provenance Matto Grosso performed well. This shows the superiority of the MT genotypes compared to RO and AC genotypes and this is in conformity with the general observations made by IRCA (Clement - Demange *et al.*, 1990) and Saji *et al.* (1992). But for yield, the performance was comparable between the three states.

Table III gives the split up of the total variance into heritable and non-heritable components and also the heritability estimates in the broad sense and genetic advance as percentage of mean. Except for the characters height, number of whorls, number of leaves in third whorl and girth, all the other characters exhibited higher estimates of heritable portion of variance expressed as the genotypic coefficients of variation. This is evidenced by the higher estimates of heritability and genetic advance, which points to the highly heritable nature of these characters which can be used in any breeding programme for selection of parents for hybridization. The highest values for heritability and genetic advance expressed by LAI and leaf dry weight is notable. Templeton (1969) reported that the maximum values of LAI obtained after about 5 years from planting corresponded with the period of maximum dry matter production and hence LAI is an important determinant of plant productivity (Watson, 1952). Medium heritability estimates were noted for the chracters height, number of whorls and girth of the plant and the lowest heritability estimate was for the character number of leaves in the third whorl indicating the higher influence of the invironment in the expressing of this character.

Correlations provide information on the nature and extent of relationship between characters in a population thus facilitating effective selection and simultaneous improvement of two or more characters. The phenotypic and genotypic correlation co-efficients between the average juvenile rubber yield per genotype and other seven characters and three derived characters studied and their inter-se associations are presented in Table IV. The genotypic correlation coefficient between the yield and the ten characters studied are given in Fig. 1.

The average test tap yeild (over two seasons) showed positive, significant, phenotypic correlation coefficient with the characters - total height, girth of the plant, leaf area index and aerial biomass, and postitive genotypic

Table II. Comparison of mean values of wild genotypes between the three states

Traits	Mean values for the three states		
	RO	AC	MT
Total height (cm)	288.0	249.0	314.3
No. of flushes	12	10	13
No. of leaves in the 3rd flush	12	10	10
Girth (cm)	11.7	11.3	11.1
LAI	2.0	2.3	2.5
Total leaf wt. (g)	193.6	224.8	243.5
Aerial biomass (g)	1153.5	1049.0	1096.0
Test tap yield (g)	0.16	0.18	0.17
LAR	18.0	22.7	23.4
Leaf wt/unit leaf area	0.01	0.01	0.01
Leaf shoot ratio	0.22	0.29	0.31

Table III. Phenotypic and genotypic coefficients of variation (PCV, GCV), heritability (H^2) and genetic advanc (GA) as percentage of mean

Characters	PCV	GCV	H^2	GA as % of Mean
Height (cm)	1901.06	833.4	43.8	23.65
No. of whorls	248.82	113.44	45.6	44.21
No. of leaves in 3rd whorl	74.29	18.21	24.5	13.13
Girth (cm)	40.77	18.44	45.22	17.6
LAI	38.03	32.84	86.37	73.76
Leaf dry wt. (g)	3497.39	3003.51	85.88	71.17
Aerial biomass (g)	18661.86	14406.14	77.19	65.16
Test tap yield (g)	3.19	2.36	73.9	64.38
LAR	256.38	211.96	82.67	60.33
Leaf wt/unit leaf area	0.0064	0.0064	99.99	16300
Leaf shoot ratio	5.42	4.40	81.24	77.01

Table IV. Correlation among various characters studied

Traits	1	2	3	4	5	6	7	8	9	10
1 Total height										
2. No. of whorls	P.0.3127**									
	G.0.3538									
	E.0.2795									
3 No. of leaves in third whorl	P.0.1659	-0.29								
	G.0.2399	0.0329								
	E.0.1340	-0.0624								
4 Girth	P.0.7289**	0.3878**	0.1862							
	G.0.7445	0.3025	0.3617							
	E.0.7165	0.4587	0.1023							
5 LAI	P.0.3167**	0.3294**	0.0096	0.4632**						
	G.0.3831	0.3799	0.0260	0.5373						
	E.0.2927	0.3340	-0.0075	0.4662						
6 Total leaf Weight	P.0.3396**	0.3346**	0.0072	0.4821**	0.9746**					
	G.0.4203	0.3877	0.0189	0.5636	0.9710					
	E.0.2900	0.3321	-0.0046	0.4707	0.9968					
7 Aerial biomass	P.0.5639**	0.3973**	0.1243	0.7503**	0.6539**	0.6509**				
	G.0.7213	0.4580	-0.2936	0.9133	0.6581	0.6544				
	E.0.4032	0.3564	-0.0083	0.5960	0.6610	0.6582				
8 Test tap yield	P.0.2223*	0.1171	0.0407	0.3628**	0.2470	0.2858**	0.3278**			
	G.0.1995	0.1006	0.0002	0.3459	0.2605	0.3096	0.3485			
	E.0.2839	0.1557	0.0920	0.4306	0.2058	0.2039	0.2646			
9 L A R	P.-0.2484*	-0.0730	-0.1214	-0.3112**	0.4000**	0.3694**	-0.3507**	-0.1064		
	G.-0.3006	-0.0567	-0.2523	-0.3528	0.4620	0.4257	-0.2941	-0.1129		
	E.-0.2163	-0.1244	-0.0218	-0.3099	0.0622	0.0683	-0.5823	-0.0852		
10 Leaf wt/unit Leaf area	P.0.035	-0.0342	0.0047	0.0323	-0.2318*	-0.0222	-0.0860	0.1020	-0.2083*	
	G.0.1255	-0.0506	0.0098	0.0477	-0.2494	-0.0239	-0.0980	0.1186	-0.2290	
	E.0.0784	-0.0093	-0.0240	0.0583	-0.0353	-0.0215	0.0099	0.0168	-0.0085	
11 Leaf shoot ratio	P.0.2292*	-0.0785	-0.1210	-0.3114**	0.3259**	0.3436*	-0.3764**	-0.0979	0.9665**	0.0166
	G.-0.2800	-0.0749	-0 2579	-0.3624	0.3807	0.4016	-0 3330	-0.1061	0.9269	0.0185
	E.-0.1911	-0.1032	-0.0156	-0.2863	0.0437	0.0499	-0.5446	-0.0709	0.9841	-0.0046

P - phenotypic correlation coefficient, G - genotypic correlation coefficient, E - error correlation coefficient
* - significant at 5%, ** - significant at 1%

correlation with total height (0.1995), girth (0.3459), leaf area index (.2605), total leaf weight (0.3096) and aerial biomass (0.3278). Positive genotypic correlation was noted between height of the plant and the characters - number of whorls (0.3538), number of leaves in the third flush (0.2399), girth of the plant (0.7445), leaf area index (0.3831) total leaf weight (0.4203) and total dry matter content (aerial biomass) (0.7213). Moderate to high degree of genetic association was exhibited by the characters leaf area index (0.5373), total leaf weight (0.5636) and total dry matter content (0.9133) with the girth of the plant. Number of whorls of leaves showed postitive genotypic correlation with girth (0.3025) leaf area index (0.3799) and total leaf weight (0.3877). Number of leaves in the third flush showed a positive genotypic correlation with girth (0.3617) and total dry matter content (0.2936). Very high positive genotypic correlation was exhibited by the leaf area index with total leaf weight (0.9710) and also the dry matter accumulation (0.6581). Positive genotypic correlation coefficeints of 0.6544 was exhibited between the characters total leaf weight and the dry matter content. The derived characters LAR, leaf weight per unit leaf area and leaf shoot ratio showed negative genotypic correlation coefficients with girth and aerial biomass.

These results are in accordance with the reports of previous works. Gomez *et al.* (1989) has reported a very high positive correlation (r = 0.6007 **) between yield and dry matter. Diering (1987) has reported a similar correlation (r = 0.92 **) in gauyule rubber also. High significant positive correlation (r = 0.852 **) between height and girth, height and number of leaf whorls (r = 0.783 **) at 21 months age is reported of leaf whorls (r = 0.783 **) at 21 months age is reported by Momoh and Alika (1987). Licy and Premakumari (1988) has reported positive cor-

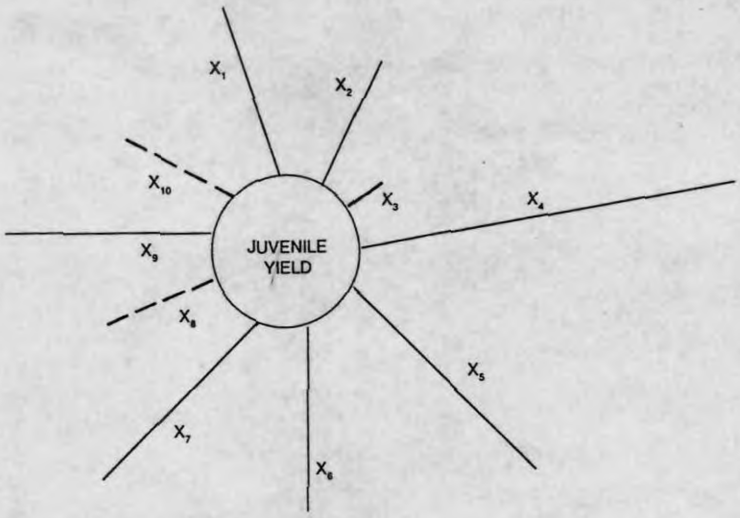
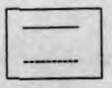


Fig. 1. Diagramatic representation of genotypic correlation between yield and other characters



X_1 - Height (cm)
X_2 No.of whorls
X_3 - No. of leaves in third whorl
X_4 - Girth (cm)
X_5 - LAI

X_6 - Total leaf wt. (g)
X_7 - Aerial biomass (g)
X_8 - LAR
X_9 - Leaf wt/unit leaf area
X_{10} - Leaf shoot ratio

relation between yield, plant height and girth in the nursery evaluated hand pollinated progenies. Photosynthetic rates (PR) of clonal seedlings are correlated to their total dry weight (DW) Anonymous (1987) and Samsudhin *et al.* (1987) has reported significant positive correlation between photosynthetic rate and yield.

The very high positive association of these characters make the simultaneous improvement of characters more easy.

The direct and indirect effects of these characters on yield is shown in Table V. The character total leaf weight is having maximum direct effect (0.75) on yield and the effect of other characters through this character on yield is also positive, indicating the importance of total leaf weight on yield in seedling stage.

The study reveals the occurrence of some wild genotypes which are performing better than the control RRII 105 for most of the secondary characters. The wide variability expressed for these characters shows the possibility of broadening the genetic base of the cultivated rubber. However, the chance for direct selection for yield from the wild population is very remote since they are very much acclimatized to the stress condition in their primary centre of origin. The general superiority of the genotypes from the state Matto Grosso compared to AC and RO genotypes shows their importance in the breeding programmes. Even then, the genotypes from all the three provenances like MT 1650, RO 1269, AC 2016 etc., having higher values than the control for the characters, total number of whorls, girth, LAI, leaf dry weight and aerial biomass are very much important for population improvement programmes. The characters, leaf dry weight and aerial biomass are very useful in the early culling out of low yielders since there is significant correlation with photosynthetic rate, thus reducing the number of progenies to be tested. Moreover, the genotypes with more dry matter accumulation (aerial biomass) are highly preferred since the exploitation of the tree by tapping affects the vigour of the tree.

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Table V. Direct and indirect effects of secondary characters on yield

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Total height(X_1 (cm)	**-0.0993**	-0.0171	-0.0027	0.2343	-0.2060	0.2544	0.0587
No. of whorls (X_2)	-0.0311	**-0.0548**	0.0005	0.1247	-0.2143	0.2507	0.0413
No. of leaves in third whorl (X_3)	-0.0165	-0.0016	**-0.0164**	0.0599	-0.0062	0.0054	0.0129
Girth (X_4) (cm)	-0.0724	-0.0216	-0.0030	**0.3215**	-0.3013	0.3612	0.0781
LAI (X_5)	-0.0315	-0.0180	-0.0002	0.1489	**-0.6506**	0.7302	0.0681
Total Leaf (g) wt. (X_6)	-0.0337	-0.0183	-0.0001	0.1550	-0.6340	**0.7493**	0.0677
Aerial biomass (g) X_7)	-0.0560	-0.0218	-0.0020	0.2412	-0.4254	0.4877	**0.1041**

Residue = .908

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DISCUSSION

R.D. IYER : In one of the Tables the wild genotype show low Test Tap Yield although leaf area index was very high. Hence there seems to be a limitation to using such correlation. Perhaps we should also go in for more conservative traits such as enzyme profiles along with phenotypic values.

M.A. MERCY : The wild genotypes were very much acclimatized to the stress condition in their primary centre of origin. Hence they were more developed for competing against the stress condition. Moreover, direct selection for yield from this wild genotypes is very remote. In the later studies we can include isozyme analysis to get clear characterization and their influence on yield.

C.S. SRINIVASAN : Residual effect from path analysis is high (.908). You have to search for other characters.

M.A. MERCY : The study is conducted at the age of 18 months and rubber tree starts tapping only at the age 7 yrs. So at 18 months old only these characters were possible to study, all the other yield attributing characters can be studied only when tapping has started. So out of the characters studied leaf weight is important, since its direct and indirect effect on juvanile yield is positive. Moreover, the yield what I meant is juvanile yield, not the mature yield.