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GENETIC EVALUATION OF WILD *HEVEA* GERMPLASM: EARLY PERFORMANCE

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ABSTRACT

The wild germplasm, is a rich source of many potential genes resistant to various biotic and abiotic stresses. The present study evaluated a set of wild genotypes in a field evaluation trial. The objectives of the study were assessment of the nature and extent of variability present in the wild germplasm, estimation of genetic parameters like heritability and genetic advance and assessment of the yielding trend in the early premature phase. A simple lattice design with 4 replications and 4 plants per plot was used. The field performance of the genotypes was compared with the popular Wickham clone RRII 105. For the morphological characters, the wild genotypes were in general more vigorous than the control in terms of a higher population mean for the girth, height, total number of leaves per plant, total leaf area of the plants and leaf area index. RO/C/9/157 was found to be a very vigorous clone with the maximum mean values for these traits. In the case of dry rubber yield recorded as the average of several test tappings in the third year, the wild genotypes were poor yielders compared to the genetically improved control clone. However, one genotype, MT/C/10/24 had a significantly higher test tap yield (4.27 g t^{-1} t^{-1}) than the control (2.35 g t^{-1} t^{-1}), while another genotype MT/C/1/91 had a yield ((2.09 g t^{-1} t^{-1}) on par with the control. Characters like dry rubber yield and certain bark structural characters were found to have high heritability and high genetic advance indicating their amenability to selection. Several genotypes could be identified as superior for certain important characters like girth, number of leaves, bark thickness, number of latex vessels, diameter of latex vessels besides test tap yield.

INTRODUCTION

The rubber plantations in the east, producing a major share of the total production, originated from a narrow genetic base. From this small genetic foundation, substantial improvement in productivity has already been achieved. However, there has been a slow down in genetic advance in the recent years, which is attributed mainly to the narrow genetic base. Hence action was initiated at the international level for enriching the original gene pool by introducing a large quantity of wild germplasm from the center of diversity, in Brazil. These are being conserved, characterised, evaluated and documented in different rubber producing countries including India with the objective of utilising them for broadening the genetic base and thereby achieving further genetic improvement of *Hevea*. The wild germplasm, is a rich source of many potential genes resistant to various biotic and abiotic stresses. Hence a systematic screening is essential for identification of valuable genotypes for direct use and / or incorporation into the breeding pool. The objectives of the study were assessment of the nature and extent of variability present in the wild germplasm of *Hevea brasiliensis*, estimation of genetic parameters like heritability and genetic advance for selected characters and assessment of the yielding trend in the early premature phase.

MATERIALS AND METHODS

Eighty genotypes belonging to the 1981 International Rubber Research and Development and Board (IRRDB) collection of wild *Hevea* germplasm planted in a field evaluation trial was used for this study. The popular clone RRII 105 was used as the control. The selected genotypes represented accessions from the three provenances of Brazil – Acre (AC), Rondonia (RO) and Mato Grosso (MT) with 25, 27 and 28 genotypes respectively. Genotypes were planted in a simple lattice design with 4 replications and 4 plants per plot in 2.5 x 2.5m spacing. In the first year after planting, morphological characters like collar girth (cm), height (cm), number of leaf flushes per plant, total number of leaves per plant and leaf area index were recorded. In the third year, bark structural characteristics- bark thickness (mm), soft bark thickness (as percentage), hard bark thickness (as percentage), total number of latex vessel rows, density of latex vessels per row per mm circumference of the plant and diameter of the latex vessels (mm) were recorded besides the test tap yield as the average of six tappings ($g\ t^{-1}\ t^{-1}$) and girth of the plants (cm). Mean, range, estimates of variability like phenotypic and genotypic coefficients of variation (PCV and GCV respectively), genetic parameters (heritability (H^2) and genetic advance (GA)) were estimated for these characters besides ANOVA.

RESULTS

Results revealed that all the wild genotypes exhibited significant differences for all the characters studied. Range of the characters studied and their mean values showed a wide range of variation for all these characters in the wild germplasm, compared to the control. For the morphological characters, the wild genotypes were in general more vigorous than the control in terms of a higher population mean for the girth, height, total number of leaves per plant and leaf area index. RO/C/9/157 was found to be a very vigorous clone with the maximum mean values for the characters girth of the plants (10.41 cm), total number of leaves per plant (119.80) and leaf area index (0.46) (Tables 1). RO/C/9/157 had the maximum girth value in the population.

The genotype RO/CM/12/136 had the maximum number of leaf flushes per plant (9.12). Control clone had an average of 6.78 flushes with a similar value as the general mean of the population (6.73). RO/C/9/157 had the maximum number of leaves (119.80 leaves). Leaf area index was found to be the highest for RO/C/9/157 with a value of 0.46, where the control clone had an index of 0.13 while the population mean was a higher index of 0.19.

The wild genotypes were found to be in general poor yielders compared to the genetically compared control clone. MT/C/10/24 had a significantly higher test tap yield (4.27 $g\ t^{-1}t^{-1}$) than the control (2.35 $g\ t^{-1}t^{-1}$). RO/CM/12/44 had the maximum proportion of soft bark zone (64.88 %) and minimum proportion of hard bark zone (35.12 %) among the wild genotypes studied. The control clone had 38.01% of its bark occupied by the soft bark zone (Table 2). A high number of

Table 1. Range and general mean of growth characters in comparison with control.

Character	Range				General mean	Control RRII 105	Computed F	CD value
	Minimum	Genotype	Maximum	Genotype				
Girth (cm)	4.72	MT/IT/16/135	10.41	RO/C/9/157	7.38	6.06	7.02**	1.34
Height (cm)	100.89	MT/IT/16/135	322.99	RO/C/8/302	191.98	145.70	5.26**	55.0
No of leaf whorls	4.89	MT/IT/16/12	9.12	RO/CM/12/136	6.73	6.78	6.46**	1.14
Total no of leaves	41.20	MT/IT/ 16/135	119.80	RO/C/9/157	69.80	62.80	6.44**	19.89
Leaf area index	0.08	MT/IT/16/135	0.46	RO/C/9/157	0.19	0.13	4.84**	0.11

** Significant at $P < 0.01$ F = 1.53

Table 2. Range and general mean of girth, yield and bark structural characters in the third year.

Character	Range				Gl. mean	Control	Computed F	CD value
	Minimum	Genotype	Maximum	Genotype				
BT (mm)	2.00	RO/CM/ 12/115	4.00	RO/C/8/ 302	2.86	3.06	164.3	0.1
Soft BT in %	31.26	RO/OP/4/ 139	64.88	RO/CM/ 12/44	42.17	38.01	49.31	3.1
Hard BT in %	35.12	RO/CM/ 12/ 44	68.74	RO/OP/ 4/139	57.83	61.99	76.0	3.1
TLVR	2.99	MT/C/ 1/116	11.01	RO/C/ 8/327	5.81	8.00	81.93	0.53
DLV/row/mm	11.50	RO/C/8/ 327	25.00	RO/CM/ 12/136	17.15	23.76	146.34	0.7
Diameter (mm)	13.44	MT/IT/ 16/12	34.00	MT/IT/ 16/2	21.46	16.30	58.63	1.4
Girth (cm)	10.38	MT/IT/ 16/135	27.06	RO/C/ 9/157	18.64	17.84	193.0	4.7
Yield ($gt^{-1}t^{-1}$)	0.0481	RO/OP/ 4/49	4.2711	MT/C/ 10/24	0.5273	2.3547	8.99	0.5

BT- Bark thickness; TLVR- Total number of latex vessel rows;
DLV- Density of latex vessels
** - Significant at $P < 0.01$ $F = 1.53$

latex vessel rows (11.01) were recorded for the genotype RO/C/8/327 while the control clone had only eight latex vessels rows and the population mean was only 3.65. The density of the latex vessels per row per mm distance was the maximum for RO/CM/12/136 with 25.00 rows followed by MT/C/10/20 (23.99) with the latter being statistically on par with control and the former with significantly higher value than that of the control (23.76). Genotype MT/IT/16/2 with a latex vessel diameter of 34.00 mm ranked first in the population. Control clone had a diameter of 16.30 mm, which was lower than the population mean (21.46 mm). Moderate estimates of PCV and GCV were recorded for the morphological characters. Leaf area index had the maximum GCV (35.34) followed by total number of leaves per plant (23.06). Yield recorded the maximum PCV and GCV (117.01 and 95.54 respectively) followed by total number of latex vessel rows (30.75 and 30.01 respectively). The difference between the PCV and GCV for bark structural characters was very low. Moderate to high heritability estimates with moderate to high genetic advance were recorded for all the characters studied with characters like girth, test tap yield and bark anatomical characters having the highest values (Tables 3 and 4).

DISCUSSION

Analysis of variance carried out revealed significant genetic differences among the genotypes for all the characters studied. Thus the inherent genetic variability in this population will enhance selection programmes and enable the breeder to apply enough selection pressure for these characters. Mydin *et al.* (1992) reported similar results of significant genetic variation for juvenile yield, total bark thickness, number of leaf flushes and number of leaves per plant, in Wickham seedling progenies.

The initial vigour and rate of growth of the wild genotypes were higher than that of the control clone in terms of mean values of the growth characters. Varghese *et al.*, (1988, 1989) and Varghese (1992) have reported similar results of

Table 3. Phenotypic and genotypic coefficients of variation, heritability and genetic advance for growth characters

Character	PCV as %	GCV as %	H^2 as %	GA as %
Girth of the plants (cm)	20.02	15.52	60.08	24.78
Height of the plants (cm)	26.28	19.68	56.08	30.36
No of leaf flushes per plant	18.13	13.78	57.71	21.56
Total no of leaves per plant	30.37	23.06	57.65	36.06
Leaf area index	50.48	35.34	48.99	50.95

Table 4. Phenotypic and Genotypic coefficients of variation, heritability and genetic advance for yield, girth and bark structural characters.

Character	PCV as %	GCV as %	H^2 as %	GA as %
Total bark thickness (mm)	15.73	15.53	97.61	31.62
Soft bark thickness (%)	16.60	15.87	90.50	31.10
Hard bark thickness (%)	12.16	11.57	91.00	22.68
Total no of latex vessel rows	30.75	30.01	95.24	60.34
Density of latex vessels per row per mm	18.33	18.08	97.32	36.75
Diameter of latex vessels (um)	18.05	17.42	93.20	34.65
Test tap yield ($g\ t^1\ t^1$)	117.01	95.54	66.67	160.7
Girth of the plants (cm)	29.19	23.1	62.67	38.28

wide variability in the young wild germplasm with respect to growth parameters like plant height, girth, number of leaves and number of flushes.

Leaf area index is an important factor that determines growth in pre-exploitation stage (Sethuraj, 1985). All the growth indicators, thus clearly points out the higher vigour of the wild germplasm compared to the genetically improved control clones. Test tapping in the early growth phase of the wild germplasm, was done to get a comparative assessment and indication on the yielding potential of each genotype. Even though majority of the genotypes were poor yielders compared to control, exceptional genotypes like MT/C/10/24 and MT/C/1/91 and those genotypes identified with about more than half of control yield may serve as early indications of better yielding genotypes. The generally low yielding nature of the 1981 IRRDB germplasm has already been reported from India (Abraham *et al.*, 1992; Mercy *et al.*, 1993; Madhavan *et al.*, 1993 and Rao and Reghu, 1999) in agreement with the results of this study. The wild germplasm recorded lower values for almost all the anatomical characters of virgin bark, especially in the case of number of latex vessel rows (Lam *et al.*, 1997). This can be substantiated partially by the suggestion of Wycherley (1969) that selection for high yield in the Wickham clones over the years resulted in a corresponding increase in the number of latex vessel rows in the bark. Even though similar trends were noted in this study also, there were several individual genotypes as exceptions for several bark anatomical characters either being superior or comparable to the popular control clone, RRII 105. Similar trends in the range for the characters density and diameter of latex vessels were reported by Reghu *et al.*, (1996) in a set of two-year old wild genotypes. In this study the general mean for the diameter of latex vessels was found to be higher than the improved clone RRII 105 while it was low for density of latex vessel rows.

Gilbert *et al.* (1973) was the first to report on application of biometrical analysis to rubber progeny data. Genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in the broad sense (H^2) and genetic advance (GA), help in partitioning the genetic variability into heritable and non-heritable components (Henderson, 1953). For all the characters studied in this experiment, the phenotypic coefficient of variation was always higher than the genotypic coefficient of variation. This is only natural as variability at the phenotypic level consists of both genotypic and environmental variabilities, besides the genotype-environment interaction (G x E). When the total variability for any character is contributed mainly by the genotype and is less influenced by the environmental factors the scope for selection of this character increases. In general, the morphological characters like girth, height, number of leaf flushes per plant, total number of leaves per plant and leaf area index exhibited medium to high estimates of PCV and GCV with the genetic components of the total variability dominating the contribution to the total variability. This indicates a significant involvement of genetic factors in the expression of these characters, even though they were more influenced by the environmental factors than the bark structural characters. Moderate estimates of coefficients of variation was reported by Chandrasekhar *et al.*, (1995) for height of the plants, and by Licy *et al.*, (1993) for girth in immature Wickham clones and by Abraham *et al.*, (1992) in two-year old wild genotypes for girth and height, in agreement with the present study. Medium to high coefficients of variation were recorded for bark structural characters with narrow differences between PCV and GCV, showing the negligible influence of the environment in the expression of these characters. Chandrasekhar *et al.*, (1995) reported moderate estimates and Mydin (1992b) reported higher estimates of genotypic variability for the total number of latex vessel rings. Licy *et al.*, (1992) had medium estimates for the characters, total number of latex vessels and total bark thickness in immature Wickham clones. Abraham *et al.*, (1992) had reported in wild genotypes, medium estimates of PCV and GCV for total bark thickness, total number of latex vessels and density of latex vessels, which were in accordance with the results of this study. The test tap yield recorded very high estimates of PCV (117.01) and GCV (95.54). Mydin *et al.*, (1992b, 1996) have reported the highest genotypic coefficient of variation of the juvenile rubber yield in two year old Wickham progenies.

Heritability in the broad sense and genetic advance were found to be medium to high for all the morphological and bark anatomical characters indicating the presence of additive gene action in the inheritance of these characters. Moderate to high H^2 for girth and number of leaf flushes (Mydin *et al.*, 1996) and for height (Chandrasekhar *et al.*, 1995) in immature Wickham clones and medium H^2 estimates for single leaf area (Rao and Reghu, 1999), height of plants (Abraham *et al.*, 1992, Mercy *et al.*, 1993a and Rao *et al.*, 1999) and number of flushes (Mercy *et al.*, (1993a) in young wild genotypes was in accordance with the present results. Mydin *et al.*, (1996) reported moderate heritability estimates for bark thickness and number of latex vessel rows in immature Wickham clones and Abraham *et al.*, (1992) reported high H^2 for total number of latex vessel rows in two year old wild genotypes. All these studies were in agreement with the results of this study. The high heritability values are suggestive of the possible good response of these characters to selection.

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REFERENCES

Abraham, S.T., Reghu, C.P., Madhavan, J., George, P.J., Potty, S.N., Panikkar, A.O.N. and Saraswathy, P. 1992. *Indian Journal of Natural Rubber Research*, **5**(1&2): 195-198.

Gilbert, N, E., Dodds, K.S. and Subramaniam, S. 1973. *Journal of the Rubber Research Institute of Malaya*. **23**(5): 365-380.

Henderson C.R. (1953). *Biometrics*, 9:226-252.

Lam, L, V., Hoa, T.T.T., Ha, V.T.T. and Hong, T. 1997. *Proceedings of the IRRDB Symposium on Natural Rubbe. Vol- General, Soils and Fertilisation and Breeding and Selection Sessions.* Ho Chi Minh City-14-15 October 1997. pp 89-100.

Madhavan, J.M., Reghu, C.P., Abraham, S.T., George, P.J. and Potty, S.N. 1993. Resources of *Hevea.* Paper presented in the '*ISPGR Dialogue in Plant Genetic Resources: Developing national policy*'held at NBPGR, New Delhi, 1993.

Mercy, M.A., Abraham,S.T., George, P.J., Potty, S.N., Sethuraj, M.R. and Saraswathy, P.. 1993. *J. of Plantation Crops.* **21** (Supplement) : 268-274.

Mydin, K.K. 1992. *Genetic divergence, prepotency and inbreeding depression in Para Rubber.* Ph.D. Thesis. Kerala Agricultural University, Trichur. 321p.

Mydin, K.K., Nair, V.G., Sethuraj, M.R., Panikkar. A.O.N., Nazeer, M.A. and Saraswathy, P. 1996. *Indian J. of Nat. Rubb. Research,* 9(1); 63-66.

Reghu, C.P., Abraham, S.T., Madhavan. J., George. P.J., Potty, S.N. and Leelamma, K.P. 1996. *Indian Journal of Natural Rubber Research,* 9(1): 28-31.

Sethuraj, M.R.1985. Physiology of growth and yield in *Hevea brasiliensis. Proceedings of the International Rubber Conference,* 1985, Kuala Lumpur, Malaysia, V 3, pp. 3-19.

Varghese, Y.A., Marattukalam, J.G., Premakumari, D. and Panikkar, A.O.N. 1988. *Colloque Hevea* 88, IRRDB, Paris. pp 353-364.

Varghese, Y.A., Marattukulam, J.G., George, P.J. and Panikkar, A.O.N. 1989. *J.Plant. Crops.* **16** (supplement): 335-342.

Wycherley, P.R. 1969. *J. Rubb.Res.Inst. Malaya,* **21**(1): 38-55.