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PROGENY TEST OF EARLY *Hevea* HYBRIDS FOR PRODUCING RAPID-GROWING AND HIGH-YIELDING ORTETS

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ABSTRACT

An assessement was made of a twelve-month old nursery progeny test of *Hevea* hybrids in order to select and recombine the high latex-yielding *Hevea* trees which had a rapid growth rate. The plant materials grown for the study included open-pollinated progenies, progenies of F_1 backcrossed to primary clones of *Hevea brasiliensis*, progenies of F_1 hybrids crossed with F_1 hybrids and progenies of open-pollinated *Hevea brasiliensis* used as control. A number of characteristics such as yield of dry rubber per tapping by Mendes early test, plant height and stem diameter were assessed. The preliminary results showed that the progeny of selected F_1 wind-pollinated hybrids (illegitimate) was significantly more productive than F_1 hybrids backcrossed to *Hevea brasiliensis*. Likewise, the same progeny of F_1 hybrids was significantly faster in growth compared with progeny of primary clones of *Hevea brasiliensis* similarly open-pollinated.

INTRODUCTION

Improvement of perennial crops in general, and *Hevea* in particular, naturally involves long periods of time even for a single selection and breeding cycle. This lengthy period of time is partially a consequence of the fact that many species of trees require several years (often 7 or more) to reach sexual maturity. Of even more importance, however, in the fact that final evolution is not complete until many years after the tree becomes tappable. Consequently there is a great need for procedures to evaluate selected individuals at younger ages.

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Among the eleven species actually known in the genus, *Hevea brasiliensis* and *H. benthamiana* are the best in terms of latex yield. Although their optimum environmental requirements are similar, each species has adaptative and morphological attributes which make it more suitable than the others under certain circumstances. In the wild, *H. brasiliensis* may attain a height of 15 to 40 m, and occasionally even 50 m. It is one of the species most severely affected by South American Leaf Blight (SALB) caused by the fungus *Microcyclus ulei.* On the other hand, *H. benthamiana* is a small to medium-size tree that grows up to 20-25 m and is more tolerant to SALB. Both species are indigenous to the Amazon region and are geographically isolated from each other.

Numerous inter and intraspecific crosses have been attempted between these two species (Gonçalves *et al.*, 1983). However, there is little descriptive information about first and second breeding generations. The question of relationships between the species is not a new one, but it has generally been assumed that they are freely intercompatible (Seibert, 1947; Baldwin Junior, 1947).

Selection procedures from hand pollination to large-scale clone trials have been the backbone of the breeding work at the Brazilian National Center for Rubber since 1978. The breeding program is mainly directed toward the production of improved materials in the form of clones by the traditional breeding method followed by progeny testing of superior *Hevea* phenotypes, which is necessary before the genetic worth of the individual selection can be ascertained.

Since comparison of family performance in *Hevea* breeding has received attention from *Hevea* breeders only in the last 10 to 15 years, Simmonds (1969) and Gilbert *et al.* (1973) suggested that latex yield variation among individual families in *Hevea* could be accounted for by additive variance.

The objective of the present paper is to study 10 families representing three hybrid types to determine the feasibility of combining high yield with rapid growth and to provide additional information on *Hevea* breeding.

MATERIAL AND METHODS

The technique used for controlled *Hevea* pollination at the Brazilian National Center for Rubber was that described by Djikman (1951).

The parental clones used in the experiment were:

IAN 873 – The progeny of a cross between PB 86 and FA 1717 which were the primary clones from Malaysia and Brazil, respectively (both *H. brasiliensis).*

Fx 3810 – The progeny of a cross between F 4542 (*H. benthamiana*) and AVROS 363 (*Hevea brasiliensis*) which were the primary clones from Brazil and Sumatra, respectively.

Fx 3899 – The progeny of a cross between F 4542 (*H. benthamiana*) and PB 86 (*Hevea brasiliensis*) which were the primary clones from Brazil and Malaysia, respectively.

Fx 4098 – The progeny of a cross between PB 86 and FB 74, both primary clones from Malaysia and Brazil, respectively (both *H. brasiliensis*).

PFB 5 – A primary clones of *H. brasiliensis* selected in Belterra.

The seeds produced by hand pollination were planted in polybags and, at the three-whorls leaf stage, the seedlings were transferred to the field nursery at the spacing of 1.2 m x 1.2 m.

The plant materials grown for the study included:

Group 1 – Open-pollinated progenies.

Group 2 – Progenies of F_1 backcrossed to primary clones of *Hevea brasiliensis.*

Group 3 – Progenies of F_1 hybrids crossed with F_1 hybrids.

Group 4 – Progenies of open-pollinated *Hevea brasiliensis* used as control.

During the first year, data on yield and growth vigor from each tree in the experiment were taken in August 1983. Growth vigor of the seedlings was expressed by stem diameter and height. The former was measured at 40 cm from the ground. Yield was estimated by the early test method utilized in Brazil (Mendes, 1971) for testing progenies for selection. The average yield per ortet per tapping for each round of tests in milligrams of rubber was obtained by dividing total yield by the number of recordings for a particular test. Tapping was done using a special knife (Mendes' Knife) in an alternate day system.

The experiment was arranged in a randomized complete block design with three replications, 10 treatments (progenies) listed in Table I, and eight plants per lot. Extra seedlings in each plot were used for border rows.

In addition to the above independent variables, the within-plot coefficients of variations for each character were analyzed. Differences among groups and among within-group progenies were tested by analysis of variance followed by planned orthogonal comparisons. These differences were tested for statistical significance at the 0.01 level.

RESULTS AND DISCUSSION

Measurements of plant height and stem diameter for the first year progeny test are summarized in Table I. Progenies of open-pollinated hybrids (Group 1) showed significant differences in height when compared with the other groups. Stem diameter and yield did not differ significantly.

Table I -Summary of measurements in a first-year progeny test of rubber hybrid families.

Group and family lots in groups	Height (m)	Stem diameter (m)	Yield by the Mendes early test (mg)
Group 1 (Progeny of open pollinated hybrids)			
IAN 2388 x ill.	2.118	1.970	116.330
Fx 3899 x ill.	2.290	1.981	127.102
Fx 3810 x ill.	2.129	1.888	71.345
Mean	2.179	1.946	104.925
Group 2 (Progeny of F_1 backcrossed to *Hevea brasiliensis)*			
Fx 3899 x PFB 5	2.039	1.957	79.922
Fx 3810 x PFB 5	1.926	1.840	63.487
Fx 4098 x PFB 5	1.885	1.647	68.240
Mean	1.950	1.814	70.841
Group 3 (Progeny of F_1 hybrids)			
Fx 3810 x IAN 873	2.143	2.269	118.154
Fx 3899 x Fx 3810	1.850	1.661	62.325
Mean	1.996	1.965	94.975
Group 4 (Progeny of open-pollinated *Hevea brasiliensis)*			
PFB 5 x ill.	1.938	1.820	77.085
IAN 873 x ill.	1.825	1.925	110.247
Mean	1.881	1.870	93.05

LSD - Height = 0.150; stem diameter = 0.170; yield = 37.639.

The progenies of F_1 backcrossed to *Hevea brasiliensis*, in Group 2, differed significantly in average plant height and stem diameter among themselves. Progenies Fx 3899 x PFB 5 exceeded the control mean in height. Within Group 3, differences among families were significant for both growth vigor and yield. One of these families exceeded the control in height and stem diameter, while another Fx 3899 x Fx 3810

was outgrown by the control. In the same group, mean yield was slightly higher (94.75 mg) when compared with the control (93.05 mg).

The gains of selected backcross hybrids (Group 2) are the most meaningful because these progenies of F_1 hybrids backcrossed to *H. brasiliensis* have the greatest potential for combining the desired growth in stem diameter and yield in a new *Hevea* plant. However, gains in yield were not limited to them. The progeny of F_1 backcrossed to *H. brasiliensis* (Group 2) and the progeny of F_2 hybrids (Group 3) were not significantly different in growth vigor (height and stem diameter) from the progeny of open-pollinated plants (Group 1). Conversely, Group 1 had a higher yield in milligrams of dry rubber per ortet than did Groups 2, 3 and 4, although not significantly. Hence, plants of Group 3 have a significantly larger stem diameter over the *H. brasiliensis* control. From this, we may deduce that the same plants would probably have a stem growth advantage over all groups.

A major theoretical problem in hybrid breeding is the prospect of segregation in the F_2 and subsequent generations. According to La Farge and Kraus (1977), in a polygenic system the variability of the F_2 generation is expected to be greater than that of either the F_1 or parental generations. At least this is the expectation if the parents are inbred and relatively homozygous, which probably is not the case with outcrossing species such as *H. brasiliensis* and *H. benthamiana.*

The F_1 selections (Group 1) and selected backcrosses (Group 2) are thus two different kinds of F_2 hybrids. F_1 hybrids, however, were not tested in this study. According to genetic theory, the variation within each F_3 family is less than that of F_2 but greater than the variation in the F_1 or parental generations (Mather and Jinks, 1971).

According to Subramanian (cited by Napitupulu, 1973) heritability of yield and girth in *Hevea* has indicated that additive combining abilities predominate in the variance of yield and girth. He also stated that family prediction and phenotypic selection are effective in *Hevea* breeding. Hence, the F_2 provides an opportunity for the selection of the best families and ortets within these families.

To investigate the relative trends of variation due to segregation in this study, within-plot coefficients of variation for each family and for each character were analyzed. Results are summarized in Table II. From the analysis of variance (Table III) the differences among Families within Group 3 were highly significant for both height and stem diameter. One of the families within Group 3 exceeded *H. brasiliensis* controls in height stem diameter and yield. The other family, Fx 3899 x Fx 3810, perfomed poorly for these stem diameter traits as did the control.

Gains in yield and growth vigor were not limited to the progenies of F_1 wind-pollinated hybrids (Group 1). The progenies of F_1 hybrids representing Group 3 were taller, but not significantly different from the progenies of the other groups.

A planned orthogonal comparison revealed statistical singnificance for height.

Table II - Summary of within-plot coefficients of variation for three principal measurements in a progeny test of rubber hybrid families.

Group and family lots in groups	Coefficient of variation for		
	Height (m)	Stem diameter (m)	Yield by the Mendes early test (mg)
Group 1 (Progeny of open-pollinated hybrids)			
IAN 2388 x ill.	27.037	29.166	86.776
Fx 3899 x ill.	43.668	50.505	92.873
Fx 3810 x ill	19.428	24.361	95.492
Mean	30.044	34.677	91.713
Group 2 (Progeny of F_1 backcrossed to *Hevea brasiliensis*)			
Fx 3899 x PFB 5	20.426	19.574	62.929
Fx 3810 x PFB 5	21.907	54.237	47.422
Fx 4098 x PFB 5	34.651	37.178	59.392
Mean	25.661	37.033	56.581
Group 3 (Progeny of F_1 hybrids)			
Fx 3810 x IAN 873	21.230	21.447	62.249
Fx 3899 x Fx 3810	18.482	20.503	80.199
Mean	19.856	20.975	71.224
Group 4 (Progeny of open-pollinated *Hevea brasiliensis*)			
PFB 5 x ill.	31.223	29.853	60.120
IAN 873 x ill.	18.061	43.668	58.573
Mean	30.538	35.760	59.347

The progenies of open-pollinated F_1 hybrids (Group 1), of similarly pollinated F_1 hybrids (Group 1) and those of similarly pollinated *Hevea brasiliensis* (Group 4) were collectively higher in height than the F_1 backcrossed to *H. brasiliensis* (Group 2) and the progenies of F_1 hybrids.

Table III - Analysis of variance of orthogonal comparisons among groups of hybrid families in a first-year progeny test.

Sources of variation	Degree of freedom	Mean square for		
		Height (m)	Stem diameter (m)	Yield by Mendes early test (mg)
Block	2	0.07073	0.06942	44.36120
Progeny	9	0.11772**	0.13787*	2.719.13092
Within Group 1	2	0.02775	0.00768	3.075.11925
Within Group 2	2	0.01902	0.00739	209.82510
Within Group 3	1	0.12907**	0.55389**	6.300.82820
Within Group 4	1	0.45046**	0.33559**	6.437.59659
Group 1 vs. Group 4	1	0.0040535	0.0433402	2.00704
Group 2 vs. Group 3	1	0.0078027	0.0814205	2.098.1232
Group 1 + 4 vs. Groups 2 + 3	1	0.3745301**	0.0998787	5.027.7343
Error	18	0.02749	0.03522	1.718.96710

*Significant at the 0.05 level; **significant at the 0.01 level; Group 1 = progeny of F_1 hybrids open-pollinated (illegitimate); Group 2 = progeny of F_1 backcrossed to *Hevea brasiliensis*; Group 3 = progeny of F_1 hybrids crossed with F_1 hybrids; Group 4 = progeny of open-pollinated *Hevea brasiliensis*.

The low variability in Group 3 for stem diameter and height is an intriguing problem. According to Mendelian principles, we should expect smaller coefficients in the F_1 hybrids (Group 4) than in the progenies of controlled pollinated F_1 hybrids (Group 3) which represent a putative F_2 generation. Only for latex yield were the coefficients of variability higher in the F_2 hybrids.

The high vigor of stem diameter in Groups 1 and 2 is probably accounted for by the material used as receptor parent that originated from an interspecific cross of *Hevea brasiliensis* and *Hevea benthamiana*. It should be noted that this high vigor in F_1 suggests a high additive genetic variance for variations in stem diameter in *Hevea*. Sharp (1940, 1951) and Ross and Brookson (1966) compared the performance of progenies of the different crosses and recommended further exploitation of the best parents and crosses. In addition, in the last decade a few researchers analyzed the results obtained by the above authors using known biometrical models and reported high additive genetic variance for variations in yield and stem diameter in *Hevea*

(Simmond, 1969; Gilbert *et al.*, 1973; Nga and Subramanian, 1974; Tan and Subramanian, 1975). Hence, the additive genetic variance appears to be more important than the non-additive genetic variance in governing the variation of stem diameter for the initial *Hevea* breeding materials studied.

CONCLUSIONS

The results of this study support the conclusion that desirable characters such as good growth vigor and high latex yield evaluated and selected on the basis of progenies of F_1 hybrids may be transferred to the progenies in F_2 hybrids. The present study needs more time to be concluded and will be extended to additional groups of different hybrids. Results obtained from other progeny studies further confirm the above conclusion. However, such a conclusion connot be considered to be fully reliable until these trees are at least 13 years old, when, besides the additional hybrid material, there will be additional ramets from the selected ortets being tested in the field to supplement the results of this study.

RESUMO

Foi conduzido um teste de progênie em famílias de seringueira de doze meses de idade com o objetivo de se combinar características de produção e vigor. Foram utilizados no estudo, progênies de polinização aberta, progênies de clones F_1 retrocruzados com clones primários de *Hevea brasiliensis*, progênies de híbridos F_1 cruzados com híbridos F_1 e progênies resultantes de polinização aberta de *H. brasiliensis*, utilizada como controle. Foram avaliados caracteres de produção de borracha seca por corte pelo teste de Mendes, altura da planta e diâmetro do caule. Os resultados preliminares mostraram que progênies de híbridos F_1 originados de polinização aberta (ilegítimos) foram de maneira significativa mais produtivos do que os híbridos F_1 retrocruzados com *H. brasiliensis*. Da mesma forma, progênies de híbridos F_1 de polinização aberta foram significativamente de crescimento mais rápido quando comparado com progênies de clones primários de *H. brasiliensis* de polinização aberta.

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