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EFFECT OF SELFING IN RUBBER (*HEVEA BRASILIENSIS*)

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ABSTRACT

The methods of selfing viz., conventional hand pollination and bagging unemasculated panicles were attempted in four clones (RRII 105, RRIM 600, Tjir 1 and PB 86) of *Hevea brasiliensis* along with observations under open pollination. Fruit set, seed weight and germination percentage were recorded. Seedlings were raised from the germinated seeds and survival rate, plant height, girth, number of leaf flushes, bark thickness, latex vessel rows and juvenile yield were recorded at two years growth.

In general, selfing led to reduced seed yield. Fruit set varied with the treatments and clones. Selfing by controlled pollination gave 1.35% fruit set in comparison to 0.64% under open pollination. Per cent pollination success and per cent abnormal seeldings were more in RRIM 600. There was not much variation in seed weight and germination percentage between the treatments. In general, growth, anatomical characters and juvenile yield were lesser for plants raised from the selfed seeds. Inbreeding depression in terms of percentage decrease in vigour and juvenile yield for the different characters were apparent especially in RRIM 600 and PB 86. However, inbreeding depression for the characters studied was mostly negative in the clones Tjir 1 and RRII 105. The results emphasize the need for detailed assessment of the extent of inbreeding deprssion in *Hevea* cultivars to aid parental selection.

INTRODUCTION

In order to formulate sound breeding strategies it is vital to understand the reproductive biology and breeding system of the crop species concerned. *Hevea* is predominantly an open-pollinated crop which shows both inbreeding depression and heterosis. Whereas heterosis can be exploited for crop improvement, the consequences of inbreeding have to be given due care in parental selection in breeding programmes and also to develop component clones in seed orchards. While the extent and variability of inbreeding depression have been investigated in several parennial crops (Libby *et al.*, 1981; Eldridge and Griffin, 1983; Wilcox, 1983), information on inbreeding in *Hevea* is scanty except a few preliminary reports (Dijkman, 1951; Sharp, 1951; Brookson, 1953; Tan and Subramaniam, 1975; Simmonds, 1989). This paper deals with the effects of selfing in *Hevea brasiliensis* and extent of inbreeding depression.

MATERIALS AND METHODS

Mature trees of clones RRII 105 (Tjir 1 x Gl 1), RRIM 600 (Tjir 1 x PB 86 (both are primary clones) of *H. brasiliensis* (Willd. Ex. Adr. de Juss) Muell. Arg. were chosen for the studies. Selfing was done by conventional hand pollination and bagging unemasculated panicles with butter paper bags. Simultaneously female flowers were counted and labelled to ascertain the rate of fruit set after natural open pollination. Selfing was carried out during 1988 and 1989 flowering season. A few fruits were also harvested from monoclonal area of Tjir 1 and PB 86 to supplement the population of selfed progenies from these two clones.

Seed were germinated and planted in the nursery at the Rubber Research Institute of India (60 x 60 cm spacing) employing randomized block design with two replications. Observations were taken on 15 plants per plot selected at random, at the age of two years. The characters recorded were seed weight (g), germination (%), survival at 2nd year (%), frequency of abnormal seedlings (%), growth characters such as total plant height (cm), girth at collar region (cm), number of flushes, anatomical characters such as bark thickness (mm), number of latex vessel row and juvenile yield (g/t/t) by test tapping method. Inbreeding depression (ID) was estimated as follows :

$$I.D. = \frac{S_o - S_1}{S_o}$$

Where S_0 = mean value of open-pollinated progenies
S_1 = mean value of selfed progenies.

Test of significance for inbreeding depression was done by 't' test. Significance of I.D. was tested with the table value of 't' at error d.f.

RESULTS AND DISCUSSION

Number of pollination done and per cent fruit set obtained after self-and open-pollination are given in Table I. Among the two selfing treatments hand pollination resulted in higher seed set than that when unemasculated flowers were bagged and allowed to pollinate. Fruit set after bagging indicate selfing and provides measure of self-fertility.

Among the four clones studied, RRIM 600 recorded the highest fruit set in all the treatments (Table 1), whereas Tjir 1 recorded the lowest values which indicate the comparatively higher rate of self fertility in RRIM 600. The low fruit set in Tjir 1 can be related to either its low self fertility rate due to pre-or post-fertilization barriers or high rate of elimination of lethals in the embryonic development stage resulting in fruit abortion. Reverse trend was noted in RRIM 600. A higher fruit set in RRIM 600 and lower fruit set in Tjir 1 following selfing was reported by Tan and Subramaniam (1975) under Malaysian conditions. A mean fruit set of 1.35% was observed for conventional hand pollination followed by 0.24% in bagging and 0.64% in open pollination. The actual out crossing rate for any particular seed crop of an individual tree will be determined by a variety of genetic and environmental factors including self-fertility (Eldridge and Griffin, 1983), flowering phenology relative to neighbouring trees in the stand (Griffin, 1980) and weather conditions during the flowering period which influence pollinator activity (Yeang *et al.*, 1986).

Data on germination and survival (Table II) show relatively lower values for both the characters in the case of selfed progeny than in open pollinated progeny. On the other hand, frequency of abnormal seedlings was more after selfing as normally expected. Clonal differences were observed with respect to these characters. Germination was highest in RRII 105 (S_0 = 90%, S_1 = 88%) and lowest in PB 86 (S_0 = 70%, S_1 = 63%). Relative germination and survival in selfed progeny over open-pollinated progeny ranged from 82.05 (Tjir 1) to 97.82 (RRII 105) and from 79.17 (RRII 105) to 96.26 (PB 86) respectively. The clone Tjir 1 recorded the highest survival rate and lowest frequency of abnormal seedlings in both selfed and open pollinated progenies. Just the reverse was the case with RRIM 600 (Table II). Tan and Subramaniam (1975) reported higher frequency of runts in RRIM 600 and lower in Tjir 1 in a 5 x 5 diallel cross. In a highly heterozygous cross fertilizing sp. like *Hevea*, the clones may be heterozygous for many lethal or sublethal genes. These clones when inbred, result in segregations of homozygous recessive types like chlorophyll deficient plants, dwarf types or other monstrosities. The frequency of such lethals or sub-lethals which can be classified as runts/abnormal

Table I. Fruit set (%) after self-pollination and open-pollination

Clones	Selfing		Open pollination
	Conventional hand pollination	Bagging unemasculated panicles	
RRII 105	2484 (1.81)	2707 (0.25)	1110 (0.36)
RRIM 600	1201 (2.49)	1422 (0.28)	1088 (1.47)
Tjir 1	1266 (0.24)	1110 (0.09)	1612 (0.31)
PB 86	1025 (0.29)	1074 (0.28)	1034 (0.58)
General Mean	(1.35)	(0.24)	(0.64)

Table II. Germination, survival and frequency of abnormal seedlings after open-pollination (S_0) and selfing (S_1)

Clone	Germination (%)		Survival (%)		Frequency of abnormal seedlings	
	S_0	S_1	S_0	S_1	S_0	S_1
RRII 105	90.00 (100.00)	88.04 (97.82)	74.07 (100.00)	58.64 (79.17)	12.5	20.00
RRIM 600	83.33 (100.00	80.55 (96.68)	60.00 (100.00)	50.56 (84.27)	33.33	50.00
Tjir 1	86.67 (100.00)	71.11 (82.05)	76.92 (100.00)	62.50 (81.25)	2.50	5.00
PB 86	70.00 (100.00	63.33 (90.47)	62.85 (100.00)	60.00 (96.26)	13.63	33.63
General mean	82.50 (100.00)	73.26 (88.80)	68.46 (100.00)	52.30 (76.39)	15.49	27.08

Values given in parentheses relate to % of open-pollination.

seedlings is especially high in the first inbred generation. In RRIM 600, it appeared that recessive lethals are not eliminated in the early embryonic stage and consquently high fruitset and progeny having high frequency of abnormal seedlings with reduced viability .

Mean and range values for growth, anatomical characters, juvenile yield and seed weight are given in Table III. In general, selfing had no adverse effect on seed weight and the mean seed weight for selfed seed being 14.82 g and for open-pollinated seeds 14.36 g. With regard to growth and anatomical characters, general mean values were lower in selfed progenies in comparison to that in open pollinated progenies; the differences were mostly insignificant. The range for all the characters was comparatively higher in open pollinated progenies than that of selfs which indicated certain uniformity of selfed progenies. Clonal differences were noticed for the different characters studied. On an average, selfed progenies of RRII 105 recorded the highest number of flushes (6.60) and juvenile yield (2.74g) and Tjir 1 recorded the highest height (435.70 cm), girth 14.61 cm), bark thickness (3.41 mm) and latex vessel rows (8.33). On the other hand, RRIM 600 recorded lowest values with respect to number of flushes (4.89), bark thickness (2.65 mm), latex vessel rows (d6.40) and juvenile yield (1.82 g/t/t). The clone PB 86 also recorded relatively lower mean values. When all the characters are considered together, selfed progenies of RRIM 600 and PB 86 recorded a 10% and 20% loss respectively. The magnitude of such loss was considerably low in RRII 105 and Tjir 1.

Per cent shift in mean growth and anatomical characters of selfed progenies over open-pollinated progenies with respect to germination, survival, plant height, girth, number of flushes, bark thickness, number of latex vessel rows and juvenile yield are shown in Fig. 1. In selfed generation, there was a gradual shift for juvenile yield in RRII 105 and Tjir 1, over open-pollinated progenies, though the magnitude of shift over means, is relatively low. RRIM 600 and PB 86 showed negative shift in all the characters after selfing.

Inbreeding depression of selfed progenies computed for the different characters reveal clonal differences (Table IV). Depression was observed for all the characters except for girth. Inbreeding depression in general, was negative and low for most of the characters in RRII 105 and Tjir 1. The highest mean value was recorded

Table III. **Mean and range of growth, anatomical characters, juvenile yield and seed weight of open- polinated (S_0) and selfed (S_1) progenies.**

Clones	Plant height (cm)		Girth (cm)		No. of flushes		Bark thickness (mm)		Latex vessel rows		Juvenile yield g/t/t		Seed weight (g)	
	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1	S_0	S_1
RRII 105	393.23	406.11	9.44	12.51	6.31	6.60	3.71	3.35	7.40	7.32	2.67	2.74	16.75	15.72
	(195-	(300-	(5.3-	(9.0-	(2.0-	(3.0-	(2.0-	(2.0-	(6.0-	(6.3-	(0.3-	(1.1-	(14.4-	(14.5-
	675)	565)	16.0)	16.0)	9.0)	6.0)	6.3)	4.0)	9.6)	9.0)	5.9)	(6.0)	16.7)	14.4)
RRIM 600	430.14	389.05	12.51	11.05	5.89	4.89	3.45	2.65	8.01	6.40	2.73	1.82	12.38	12.41
	(250-	(200-	(9.0-	(4.0-	(3.0-	(3.0-	(2.0-	(2.0-	(6.4-	4.7-	(0.9-	(0.9-	(11.5-	(11.8-
	605)	535)	19.0)	14.5)	8.0)	7.0)	5.0)	4.0)	10.3)	8.0)	5.7)	3.5)	13.8)	13.4)
Tjir 1	457.02	435.70	13.80	14.61	6.61	6.00	3.10	3.41	7.62	8.33	2.59	2.61	13.86	13.87
	(131-	(200-	(8.7-	(6.2-	(4.0-	4.0-	(2.0-	(3.0-	(5.7-	(5.3-	(0.1-	(0.2-	(12.1-	(10.3-
	756)	706)	28.2)	20.0)	10.0)	10.0)	4.5)	4.5)	12.3)	12.0)	4.0)	4.5)	(15.7)	16.0)
PB 86	353.12	357.40	10.75	9.80	5.82	5.41	3.45	2.65	6.81	6.50	2.39	2.33	16.30	15.45
	(230-	(163-	(4.0-	(6.0-	(2.0-	(3.0-	(2.0-	(2.0-	(3.7-	(3.7-	(0.1-	(0.06-	(14.9-	(14.4-
	479)	569	16.8)	13.5)	(8.0)	10.0)	6.0)	4.0)	9.7)	8.3)	4.0)	5.3)	17.4)	16.8)
General mean	408.25	404.25	11.62	11.99	6.15	5.47	3.42	2.97	7.45	7.12	2.59	2.37	14.82	14.36

Figures in parentheses indicate range

Table IV. Inbreeding depression for growth, anatomical characters, juvenile yield and seed weight in selfed and open-pollinated progenies

Clones	Plant height (cm)		Girth (cm)		No. of flushes		Bark thickness (mm)		Latex Vessel rows		Juvenile Yield (g/t/t)		Seed Weight (g)	
RRII 105	0.033	1.13	-0.324**	(3.08)	-0.047	(0.57)	0.097	(1.14)	-0.012	(0.45)	-0.026	(0.17)	0.061	(1.22)
RRIM 600	0.095	(1.14)	0.116	(1.46)	0.169*	(2.44)	0.232**	(3.36)	0.202**	(4.32)	0.332*	(2.22)	0.002	(0.97)
Tjir 1	0.047	(0.31)	-0.058*	(2.64)	0.092	(1.12)	-0.110	(1.57)	-0.091	(1.7)	-0.008	(0.02)	-0.001	(0.25)
PB 86	-0.012	(0.12)	0.090	(0.89)	0.070	(0.36)	0.231*	(2.57)	0.045	(0.65)	0.025	(0.28)	0.050*	(2.35)
't' values														

* Significant at P = 0.05, ** Significant at P = 0.01
Values in parantheses indicate 't' values

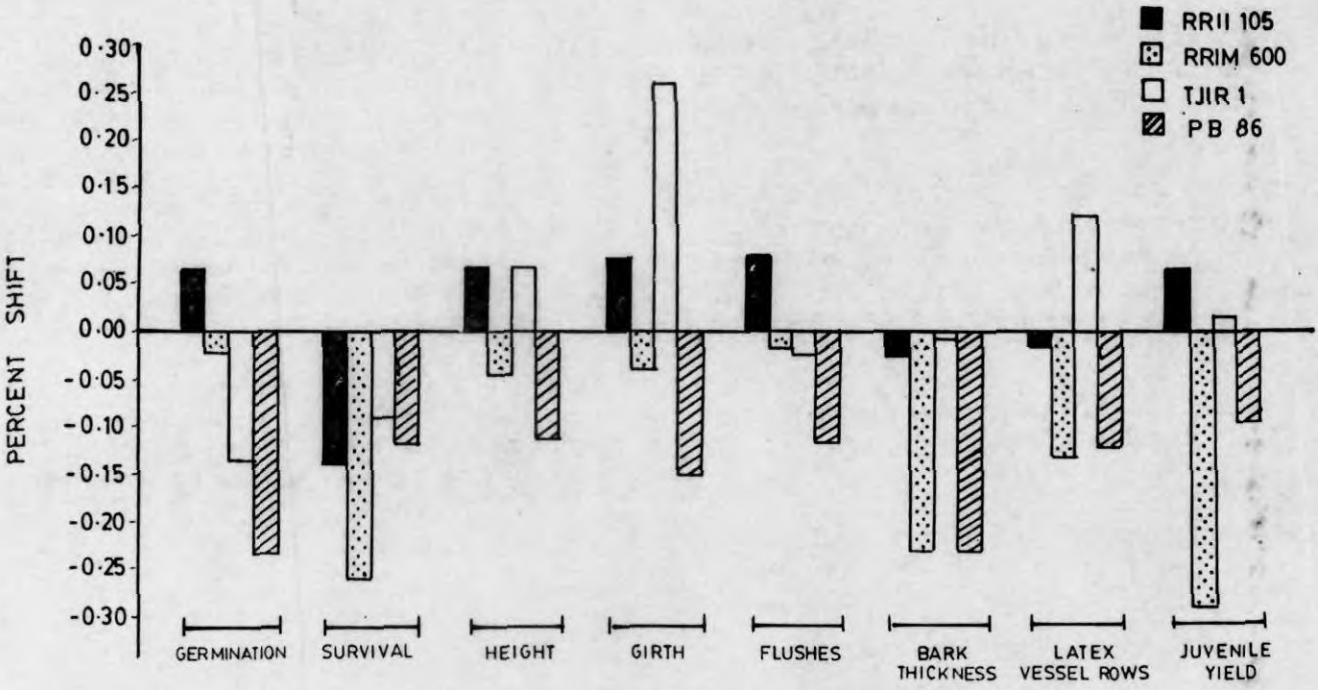

Fig. 1. Per cent shift in mean over open pollinated progenies for germination, survival, growth, anatomical characters and juvenile yield in selfed progenies.

T_1 = Germination (%)
T_2 = Survival (%)
T_3 = Plant height (cm)
T_4 = Girth (cm)
T_5 = No. of flushes
T_6 = Bark thickness (mm)
T_7 = No. of latex vessel rows
T_8 = Juvenile yield (g/t/t)

for number of flushes (0.195) and lowest for plant height (0.024). Inbreeding depression for juvenile yield was negative in the clones, RRII 105 and Tjir 1 though insignificant. Reports are available indicating low inbreeding depression in selfed progenies (Brookson, 1953) of Tjir 1. Bhaskaran Nair and Oomen Koshy (1966) also reported good performance of selfed seedlings of the clone Tjir 1.

The results reported in this paper brings to the forefront the need for detailed investigations on inbreeding depression in different cultivars of *Hevea brasiliensis*. Information on the extent of inbreeding depression in different characters in various clones will aid in the appropriate choice of clones for hybridization programme and also for inclusion in clonal orchards with specific objectives.

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