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STUDIES ON IMPROVING FRUIT SET FOLLOWING HAND POLLINATION IN *HEVEA BRASILIENSIS* (WILLD. EX ADR. DE JUSS.) MUELL. ARG.

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An attempt was made to increase fruit set following hand pollination in *Hevea*. Nine treatments comprising modifications of the conventional hand pollination procedure and methods to supplement nutrients and growth regulators were imposed during three flowering seasons. Enclosing panicles in butter paper covers of suitable size following hand pollination was found to give significantly high final fruit set than the conventional method of sealing hand pollinated flowers with cotton wool and latex. The effect of different treatments on fruit set has been discussed.

Key words — *Hevea*, Hand pollination, Fruit set.

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INTRODUCTION

The *Hevea* tree produces flowers in abundance, but even in a good flowering season, not more than three per cent of the female flowers develop into fruits (Maas, 1919; Attanayake and Sumeda, 1984). Under artificial pollination also fruit set is equally low. Several references have been made to the problem of low fruit set in *Hevea* (Warmke, 1951; Rao, 1961; Gandhimathi and Yeang, 1984). The low recovery of fruits at the mature stage poses a serious hindrance to *Hevea* breeding efforts, necessitating considerably large number of hand pollinations every year.

The low fruit set in *Hevea* may be attributed to various factors. Leconte *et al*(1984) obtained encouraging results on fruit set following use of growth regulators like Naphthalene acetic acid (NAA) and Gibberellic acid-3 (GA 3). Gandhimathi and Yeang (1984) suggested a new method of hand pollination to overcome the apparent insufficiency of pollen as a possible cause for low fruit set in *Hevea*. *In vivo* studies (Majumder, 1964) showed that addition of 0.01 per cent boric acid to sugar media markedly increased the percentage of pollen germination and length of the resultant pollen tubes in *Hevea*. Based on these observations, the present study was undertaken at the Rubber Research Institute of India Experiment Station, Kottayam, during the flowering seasons of 1986, 1987 and 1988 with a view to overcoming the problem of low fruit set by altering the conventional method of hand pollination.

EXPERIMENTAL

Nine treatments comprising methods to supplement growth regulators and nutrient media were employed. The method of Gandhimathi and Yeang (1984) to overcome insufficiency of pollen was also attempted. Another method to minimise injury to floral

parts during hand pollination was also included. The experiment was repeated on the cross combination P2 x RRII 33 during 1986 and 1988 and on the cross Ch 2 x RRII 33 in 1987. The conventional method of hand pollination was included as control. As a prophylactic measure against powdery mildew, sulphur dusting was carried out on the trees included in the experiment.

The treatments employed were as follows:

1. **Conventional method (control):** Panicles were prepared for pollination by clipping off the male flowers, immature female flowers and already opened female flowers, retaining only those female flowers which were to open on the day of pollination. The flowers were then pollinated by inserting the staminal column of mature male flowers from the selected parent, within the perianth of the female flowers after prising open the perianth lobes. The flowers thus pollinated were sealed with a plug of cotton wool and a drop of latex to keep the perianth lobes together and prevent contamination by pollen from other sources.

2. **Bud pollination:** To avoid incompatibility factors, if any, female flower buds that were to open the following day were pollinated by the conventional method.

3. **Application of NAA :** The panicles, following hand pollination by the conventional method, were sprayed with NAA thrice, at weekly intervals, the first spray being given the next day of pollination. There were two treatments employing NAA, one at 20 ppm concentration and the other at 100 ppm.

4. **Application of GA3 :** GA3 was applied at 20 ppm and 100 ppm concentrations. The treatments were given thrice at weekly intervals following conventional method of hand pollination from the first day after pollination.

5. **Boric acid : sucrose application:** A drop of an aqueous solution prepared by mixing a 0.01 per cent solution of boric acid and a 20 per cent solution of sucrose in the ratio of 1:1 by volume, was applied to the stigmatic surface using a syringe, by gently opening the perianth lobes prior to pollination. Extreme care was taken to avoid damage to floral parts. Pollination and protection of flowers were done as in the conventional method.

6. **Butter paper cover :** The panicle, following hand pollination, was enclosed in a sufficiently large butter paper cover and the open end of the cover was folded and secured properly to prevent entry of pollinating insects. Individual flowers were not sealed with cotton wool and latex. The covers were retained for two days after pollination.

7. **Soda straw method:** Individual flowers, following pollination, instead of being sealed with cotton wool and latex, were covered with a 5 cm piece of paper straw slipped over the flowers and the open end of the straw was folded back. The straw covers were retained for two days.

8. **Method suggested by Gandhimathi and Yeang (1984) :** The perianth parts of the female flowers that were to be pollinated were removed and the exuding latex blotted off with filter paper. Excised anther columns were collected in corked glass vials and kept near a lamp to enhance dehiscence. The stigma of the prepared flower was dipped into the vial containing dehisced anthers enabling sufficient pollen to stick on to the surface. The flower thus pollinated was covered with a piece of soda straw with the open end folded back. The straw covers were retained for two days.

Fruit counts were recorded at 2, 4, 8 weeks and 4 months after hand pollination.

Every year the treatments were modified on the basis of the previous years' results. In 1988, four of the more promising treatments were repeated with the conventional method as control and a larger number of hand pollinations were carried out (Table 1).

Table 1. **Hand pollinations attempted and fruit set**

	1986	1987	1988
Bud pollination	168 (3)	..	..
NAA 20 ppm	242 (6)	176 (3)	..
NAA 100 ppm	..	116 (2)	..
GA3 20 ppm	207 (8)	177 (5)	517 (24)
GA3 100 ppm	..	198 (5)	..
Boric acid: Sucrose	157 (8)	208 (11)	612 (23)
Butter paper cover	179 (10)	131 (5)	513 (26)
Soda straw method	186 (10)	187 (4)	..
Method proposed by Gandhimathi and Yeang (1984)	217 (6)	143 (5)	520 (23)
Conventional method (conrol)	223 (5)	249 (4)	573 (21)

(Figures in parenthesis indicate final fruit count)

The data on fruit set were subjected to chi-square analysis for comparison with the conventional method of hand pollination.

RESULTS AND DISCUSSION

Table 2 presents the percentage fruit set recorded at different intervals during 1986, 1987 and 1988 for the various treatments employed.

A considerably high initial fruit set was obtained irrespective of the treatments (Table 2). In 1987, initial fruit set was lower but fruit drop at various stages was much less than in 1986 and 1988. There was a heavy incidence of powdery mildew in 1987, which must have led to early drop of pollinated flowers. The high initial fruit counts two weeks after pollination and the later decrease in fruit counts could be due to the retention of any unfertilised flowers upto two weeks and their subsequent abscission coupled with immature fruit drop. The decrease in fruit drop noticed with the advancement of maturity in the present study agrees with earlier reports (Ross, 1960; George *et al*, 1967).

A comparison of the effect of five methods of hand pollination on final fruit set, over the three years of study, can be had from Figure 1.

Two methods, one using a butter paper cover to protect panicles after pollination and the other with application of boric acid: sucrose medium to the stigma prior to pollination, were found to give higher fruit set than the other methods during two of the three years of the study.

The butter paper cover method gave best results in terms of final fruit set (Table 2) when employed on a larger number of hand pollinations in 1988. The same method ranked first in 1986 and in the pooled data for the three years. Chi-square analysis of the pooled data (Table 3) showed this method to be significantly superior to the conventional hand pollination procedure.

The pooled data showed that three of the treatments gave more than 4 per cent final fruit set, while in the conventional method the percentage was only 2.87. The significantly high fruit set obtained for the butter paper cover method might be due to the reduced injury to floral parts during the process of pollination and protection of

Table 2. **Fruit set at different intervals following hand pollination in 1986, 1987 and 1988**

Treatments	Fruit set %											
	2 weeks			4 weeks			8 weeks			4 months		
	1986	1987	1988	1986	1987	1988	1986	1987	1988	1986	1987	1988
T1 Bud pollination	25.60*	..	..	7.74	..	..	4.76	..	..	1.79	..	..
T2 NAA — 20 ppm	37.60*	3.98	..	8.26	2.84	..	4.13	2.27	..	2.48	1.70	..
T3 NAA — 100 ppm	..	1.72	..	..	1.72	..	..	1.72	..	..	1.72	..
T4 GA3 — 20 ppm	57.00*	6.78	18.18	10.15	3.95	15.67*	3.86	3.95	6.00	3.86	2.82	4.64
T5 GA3 — 100 ppm	..	4.04	..	..	2.52	..	..	2.52	..	..	2.52	..
T6 Boric acid : Sucrose	56.69*	10.10*	9.80	20.38*	8.17*	7.52	8.28	6.25	5.72	5.10	5.29*	3.76
T7 Butter paper cover	37.99*	6.11	38.01*	18.99*	4.58	17.15*	5.59	4.58*	9.55*	5.59	3.82	5.07
T8 Soda straw cover	20.43	6.42	..	11.83	4.81	..	7.53	4.28	..	5.38	2.14	..
T9 Method by Gandhimathi & Yeang (1984)	25.81*	6.99	32.88*	18.43*	6.29	10.38	2.76	4.90*	4.42	2.76	3.50	4.42
Control–Conventional method	16.14	3.61	23.04	7.62	2.81	10.30	7.18	2.00	4.54	2.24	1.61	3.67

* Chi-square value for comparison with control significant at 0.05 level.

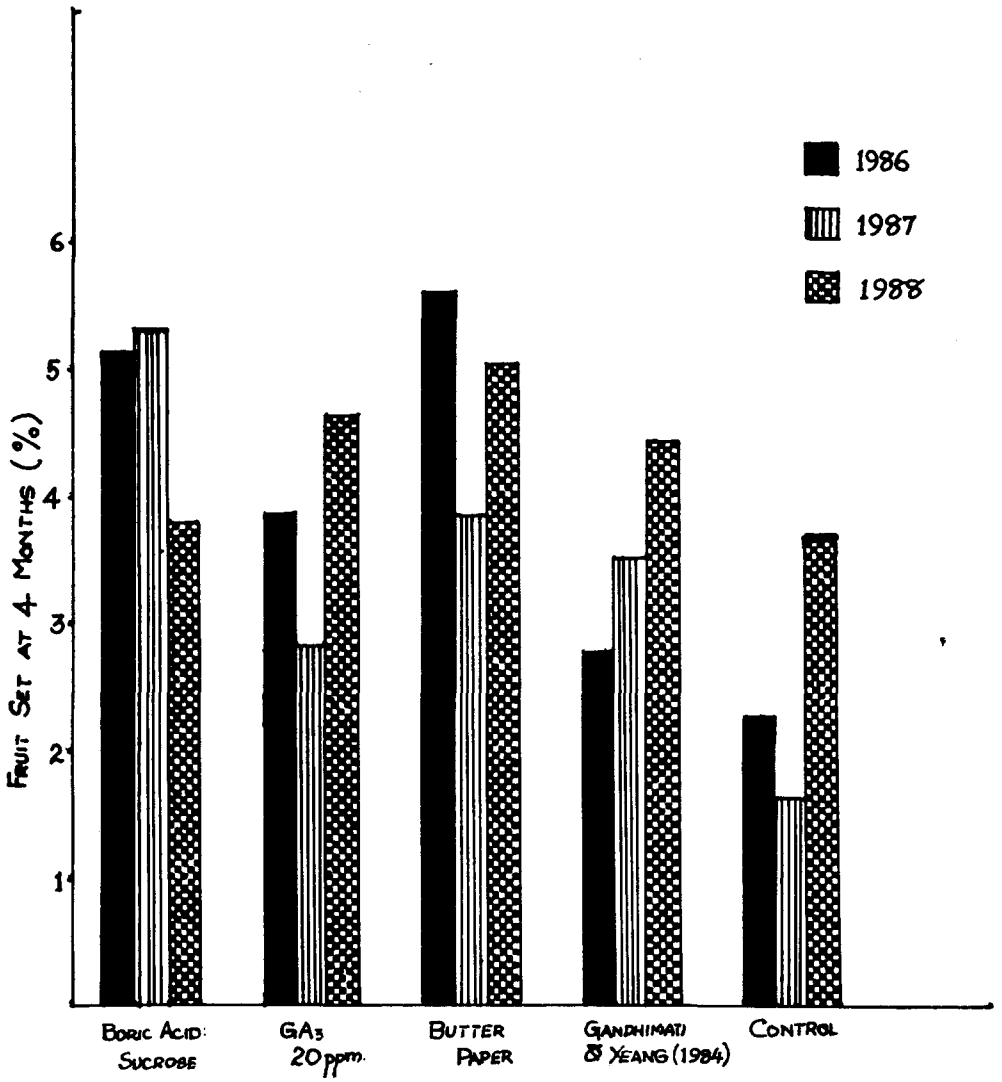

Fig. 1. Effect of hand pollination on fruit set

flowers. The conventional hand pollination procedure allows for chances of injury to the minute floral parts during the process of sealing individual flowers with cotton wool and latex and this, in turn, may affect fruit set. Sedgley and Attanayake (1986), among their recommendations for the improvement of crossing methodology, stressed the importance of handling flowers gently during pollination. Damage inflicted upon the tender flowers could further reduce fruit yield.

Table 3. **Pooled data on final fruit set**

Treatment	No. of flowers pollinated	Fruits retained till maturity	
		Number	Percentage
Boric acid : sucrose	977	42	4.30
GA3 — 20 ppm	901	37	4.11
Butter paper cover	823	41*	4.98
Method by Gandhimathi and Yeang (1984)	880	34	3.86
Conventional method (control)	1045	30	2.87

* Chi-square value for comparison with control significant at 0.05 level.

Application of boric acid: sucrose medium to flowers prior to pollination also produced promising results. The enhanced fruit set, compared to the control, could be attributed to the effect of boron in pollen germination and tube growth. The three main functions of boron with respect to pollen germination as summarised by Vasil (1960) are as follows: (1) it promotes absorption of sugars by the pollen for metabolic purposes by forming sugar-borate complexes, (2) it increases oxygen uptake and (3) it is involved in the synthesis of pectic materials for the walls of the actively elongating pollen tube. An exogenous supply of boron could , therefore, enhance pollen germination and tube growth leading to greater fertilisation success.

Application of GA3 at 20 ppm was also found to be promising, with a final fruit set of 4.11 per cent. However, as in earlier reports (Leconte *et al*, 1984) GA3 application did not allow significant differences on fruit set compared to that in the control. None of the treatments employed could raise fruit set to more than five per cent. The low fruit set in rubber has many parallels with that of the pome fruits in temperate regions (Ferwerda, 1969) and with other tropical tree crops (Hifny *et al*, 1978; John *et al*, 1987).

Analysis of the pooled data establishes the superiority of the butter paper cover method. The procedure is simple and effective and could enable a larger number of hand pollinations in a shorter time than by the conventional procedure. The ease with which the method could be carried out, coupled with the higher success in final fruit set, could help to realize a greater proportion of the crosses in hand pollination programmes.

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