J. nat. Rubb. Res., **1(3)**, 167–175

Influence of Meteorological Factors Around the Time of Hand-pollination on Hevea *Fruit-set*

H.Y. YEANG*, S.H. ONG* AND MOHD. NAPI DAUD*

Stepwise multiple regression analysis of the 1975 cross PB 5/51 × RRIM 703 showed fruit-set success to be negatively correlated with evaporation on the day of hand-pollination and postively correlated with maximum temperature; also with maximum temperature two days after pollination and relative humidity the day before. The influences of evaporation and relative humidity on fruit-setting were confirmed using a non-parametric procedure of analysis involving twenty-two crosses carried out over five years. Evaporation was also associated with the disparity in fruit-set success between the annual main and secondary flowering seasons. However, a causal relationship has not been ascertained in this instance.

In Malaysia, *Hevea* breeding entails hand-pollination of flowers during the two annual flowering seasons. The success of hand-pollination as expressed by the final rate of fruit-set is governed by several factors. Among these, the effects of pathogens, meteorological variables and competitive sinks have been noted[1,2,3]. Within the flowering season itself, there is much variation in success between days on which hand-pollination is carried out. To a large extent, this depends on the parental clones used since, in normal practice, a new cross is attempted every few days depending upon the availability of flowers from the clones selected. Nevertheless, where the variation exists for the same cross between different pollination days, other factors must be involved, meteorological influences being one obvious possibility.

In this paper, fruit-setting success is examined in relation to meteorological factors prevailing at or near the time of pollination. The disparity in success between different days of pollination as well as that between the main and secondary flowering seasons are examined.

MATERIALS AND METHODS

Multiple Regression Analysis

Data from the cross PB 5/51 × RRIM 703 carried out during the main flowering season in 1975 were used to construct a model that would relate meteorological factors to day-to-day variation in fruit-set. A total of 12 722 hand-pollinations were attempted over twelve working days, giving an average of 1060 pollinations per day.

Forward stepwise multiple correlations were carried out for fruit-set for each of the twelve pollination days against five climatic factors: rainfall, evaporation, maximum temperature, relative humidity at 1000 h and solar radiation. As it was possible that fruit-set might have been affected by meteorological influences on days near the day of hand-pollination itself, attempts were also made to fit into the equations meteorological readings relating to:

- the day prior to pollination
- the second day prior to pollination
- the day following pollination
- the second day following pollination
- summed for the day of pollination and the previous two days
- summed for the day of pollination and the following two days.

In the stepwise multiple regression of fruit-set success against the meteorological variables, the

*Rubber Research Institute of Malaysia, P.O. Box 10150, 50908 Kuala Lumpur, Malaysia

single variable that could best explain fruit-set variation was incorporated into the regression equation, this being the first step of the stepwise analysis. In the second step, the meteorological variable that could next best explain variation, with the first variable held constant, was incorporated into the equation. The procedure was continued until the addition of further variables no longer significantly increased the extent by which fruit-set variation could be accounted for statistically. Fruit-set values were logarithm transformed as preliminary analyses showed that better linear correlations could be obtained after such transformation.

Non-parametric Analysis

Data from a total of 56 122 pollinations spread over twenty-two crosses were used in the analysis. Of these, 43 052 pollinations from sixteen crosses were carried out during the main flowering seasons of 1972 and 1977. The remaining 13 070 pollinations were derived from six crosses completed in the secondary flowering seasons of 1970, 1974 and 1976. These particular years and seasons had been selected for study because of the availability of crosses with sufficient numbers of pollinations for analysis. Small samples were excluded from the analysis; thus, all crosses that had fewer than 1000 pollinations or fewer than forty-five mature fruits or fewer than four days of crossing were disregarded.

For each cross, the percentage fruit-set was calculated for each day's work. The pollination days were then assigned either as 'high fruit-set days' or 'low fruit-set days' according to whether they were above or below the median daily fruit-set for the cross. Thus, for each cross, there was an equal number of 'high fruit-set' and 'low fruit-set' days. (When there was an odd number of pollination days, the day of median fruit-set itself was excluded from the analysis.) Daily recordings of the same five parameters used in the basic analysis above (*viz.* rainfall, evaporation, maximum temperature, relative humidity at 1000 h and solar radiation) were averaged over the 'high fruit-set days' and over the 'low fruit-set days'. The same procedures were carried out for relative humidity in the morning prior to the day of hand-pollination as well as the maximum temperature two days after pollination as these two variables had been found to be significant in the regression analysis (see *'Results'* below). Thus, for each cross, two mean values were calculated for each of the meteorological variables: one being the mean for 'high fruit-set days' and the other the mean for 'low fruit-set days'. Where the meteorological mean for 'high fruit-set days' was the greater of the two means, a score of '+' was given, signifying a positive association between fruit-set and the particular meteorological variable (*i.e. high* meteorological readings associated with *high* fruit-set). Where the meteorological mean for 'low fruit-set days' was the greater of the two, a score of '−' was given, this representing a negative association (*i.e. high* meteorological readings associated with *low* fruit-set).

RESULTS

Within-season Variation in Fruit-set

Multiple regression analysis. Fruit-set on the twelve days of hand-pollination for the 1975 cross PB 5/51 × RRIM 703 ranged from 5.99% to 27.46%. Stepwise multiple regression identified the meteorological factors that *independently* contributed to this variation (*i.e.* factors explaining fruit-set variation over and above what had arisen from the interrelationships between the variables themselves). In each succeeding step of the multiple regression, meteorological variables that were too highly correlated with variables already in the model were discarded.

As shown in *Table 1*, fruit-set was found to be independently correlated to four variables, *viz.* evaporation on the day of hand-pollination *(Day 0)*, relative humidity on the morning before hand-pollination *(Day −1)*, maximum temperature on the day of hand-pollination *(Day 0)* and maximum temperature two days after hand-pollination *(Day 2)*. About 50% of the variation in fruit-set could be explained by the rate of evaporation on the day of hand-

TABLE 1. STEPWISE MULTIPLE REGRESSION OF PERCENTAGE FRUIT-SET WITH METEOROLOGICAL FACTORS

Step 1	Ln Fruit-set	=	−0.248* *−0.704*	Evaporation (Day 0)
			+3.72	R^2 = 0.496; ΔR^2 = 0.496
Step 2	Ln Fruit-set	=	−0.275*** *−0.783*	Evaporation (Day 0)
			+0.037* *0.490*	Relative humidity (Day -1)
			+1.14	R^2 = 0.730; ΔR^2 = 0.234
Step 3	Ln Fruit-set	=	−0.407*** *−1.157*	Evaporation (Day 0)
			+0.038** *0.495*	Relative humidity (Day -1)
			+0.226* *0.480*	Maximum temperature (Day 0)
			−5.59	R^2 = 0.821; ΔR^2 = 0.091
Step 4	Ln Fruit-set	=	−0.420*** *−1.197*	Evaporation (Day 0)
			+0.026** *0.342*	Relative humidity (Day -1)
			+0.331*** *0.700*	Maximum temperature (Day 0)
			+0.240** *0.412*	Maximum temperature (Day 2)
			−15.97	R^2 = 0.936; ΔR^2 = 0.115

Based on 12 722 hand-pollinations (PB 5/51 × RRIM 703) carried out over twelve days.

Ln = Logarithm transformation

Day 0 = Day of hand-pollination

Day -1 = One day before hand-pollination

Day 2 = Two days after hand-pollination

R^2 = Square of the multiple correlation coefficient (denoting the combined contributions of the considered meteorological factors to the variation in fruit-set)

ΔR^2 = Change in R^2 over that of the previous step

Standardised regression coefficients are given in italics. They are independent of the units of measurement and indicate the relative magnitude of change in fruit-set that may be effected by changes in the respective meteorological factors.

* $P<0.05$ ** $P<0.01$ *** $P<0.001$

pollination (as denoted by R^2 in *Table 1*). This figure rose to 94% when all four variables were incorporated into the equation. The relative importance of each variable could be gauged from the standardised regression coefficients attached to the respective variable *(Table 1)*. With all the four significant meteorological variables fitted into the model, the most important variable was evaporation *(Day 0)* followed by maximum temperature *(Day 0)*, maximum temperature *(Day 2)* and relative humidity *(Day -1)*. The effect of evaporation on fruit-set success was negative while the effects of the other three variables were positive.

TABLE 2. FREQUENCIES OF POSITIVE (+) AND NEGATIVE (−) ASSOCIATIONS BETWEEN FRUIT-SET SUCCESS AND METEOROLOGICAL CONDITIONS AT OR NEAR THE TIME OF HAND-POLLINATION

Type of pollination	Cross	No of pollinations	No. of fruits	No. of pollination days	Day 0 relative humidity (%)	Day 0 maximum temperature (°C)	Day 0 rainfall (mm day⁻¹)	Day 0 solar radiation (g cal⁻¹ cm⁻² day⁻¹)	Day 0 evaporation (mm day⁻¹)	Day − 1 relative humidity (%)	Day 2 maximum temperature (°C)
Main season 1972	AVROS 2037 × RRIM 600	2 378	80	6	+	−	0	−	−	−	−
	PB 5/51 × PR 107	3 082	280	8	+	−	+	−	−	+	
	PB 5/51 × RRIM 600	2 911	342	7	+	+	0	−	−	+	+
	PR 107 × PB 5/51	2 750	105	8	−	−	−	−	−	+	−
	PR 107 × RRIM 600	2 807	72	6	+	−	−	−	−	+	+
	PR 107 × RRIM 628	2 277	88	4	+	0	0	+	+	+	−
	PR 107 × RRIM 703	2 971	127	5	+	−	0	−	−	+	+
	GT 1 × PB 5/51	3 425	146	7	−	−	−	−	−	−	−
	GT 1 × RRIM 600	3 184	210	6	+	−	+	+	−	+	−
	RRIM 600 × PR 107	2 575	80	7	+	−	+	−		+	+
Main season 1977	PB 5/51 × NAB 17	2 262	130	5	+	+	+	−	−	+	+
	PB 5/51 × RRIM 803	2 686	230	6	−	+	+	+	+	−	−
	PB 260 × NAB 17	1 673	51	5	+	−	+	−	−	+	0
	IAN 873 × NAB 17	2 409	47	7	−	+	+	−	−	+	−
	IAN 873 × RRIM 803	3 404	58	5	+	+	0	+	+	+	−
	RRIM 623 × PB S/78	2 258	71	4	+	+	+	−	−	+	+
Secondary season 1970	PB 5/51 × PB 252	1 967	277	7	−	+	+	−	−	+	+
	PB 5/51 × PR 107	2 245	331	4	−	−	0	−	−	+	−
	RRIM 605 × PB 252	1 639	151	6	+	−	−	−	−	0	+
Secondary season 1974	PB 5/51 × RRIM 527	2 517	415	4	−	+	0	+	+	+	−
Secondary season 1976	PB 5/51 × RRIM 605	2 187	175	4	−	+	+	−	−	+	−
	PB 5/51 × RRIM 628	2 515	87	5	+	+	−	+	+	−	−
Frequency of positive associations (+)					14	10	10	6	5	17	8
Frequency of negative associations (−)					8	11	5	16	17	4	13
					P[a] 0.143	P = 0.500	P = 0 151	P = 0 026	P = 0 009	P = 0.004	P = 0 192

[a]Probability of outcome, or a more extreme outcome, being due to chance occurrence (one tail test)

Totals do not always add up to twenty-two (the number of crosses) as ties in meteorological readings (denoted by '0') between days with high fruit-set and days with low fruit-set have been excluded.

Non-parametric analysis. The foregoing analysis was feasible because an exceptionally large number of pollinations (12 722) of the cross PB 5/51 × RRIM 703 had been completed within a single season. Corroborative analyses using the same approach could not readily be made because pollinations on such a massive scale for a single cross are rarely attempted. Therefore, to confirm the results from the regression analysis, an alternative approach using a non-parametric procedure was adopted.

For each of the twenty-two crosses considered in the study, a score of '+' was given where a positive association was shown between fruit-set success and a given meteorological variable as explained above. Similarly, a negative association was assigned a '−' score. If meteorological variables were not correlated with fruit-set, positive and negative scores should be random. On the other hand, any bias towards either '+' or '−' scores would suggest an association of the meteorological factor with fruit-set. To determine if a predominance in the frequency of either sign was significant, the probability of obtaining the observed outcome (inclusive of outcomes even more extreme) was examined by means of a binomial assumption with $p = q = 0.5$. As can be seen from *Table 2*, significantly unequal frequencies of positive and negative scores were encountered for three of the parameters ($P < 0.05$). Significant negative associations of fruit-set with evaporation *(Day 0)* and solar radiation *(Day 0)* were found. A positive association between fruit-set and relative humidity *(Day -1)* was also observed.

That evaporation *(Day 0)* and relative humidity *(Day -1)* were found to be related to fruit-set negatively and positively in the two respective cases supports the findings of the multiple regression analysis. The third significant variable, solar radiation, could be expected to be positively correlated with evaporation and that it was also related to fruit-set was not surprising.

Between-season Variation in Fruit-set

Generally, hand-pollination during the main flowering season stretched from the end of February until the middle of April, while in the secondary season, pollination activity took place from the end of August to mid-September *(Table 3)*. The brevity of the secondary season, together with the fact that not all clones flower then limits the extent of pollination that can be attempted. Nevertheless, despite clonal variation, fruit-set success is better in the secondary flowering season than in the main season. This is clearly evident from the ten-year records between 1971 and 1980, taking all crosses for each season into consideration *(Table 4)*. The average fruit-set was 2.94% and 8.13% for the main and secondary seasons respectively, giving a mean seasonal difference of 5.2% over the ten years. Pathogen attack on flowers and competition for nutrients or other growth factors have been mentioned as possible causes for the difference[1,2,3]. A study was made to assess the possibility that the discrepancy might also be partly explained by the meteorological conditions prevailing during the flowering seasons.

TABLE 3. DURATION OF *HEVEA BRASILIENSIS* HAND-POLLINATION AT THE RUBBER RESEARCH INSTITUTE OF MALAYSIA, 1969–83

Hand-pollination	Main flowering season	Secondary flowering season
Commenced	26 February ± 16 days	24 August ± 8 days
Ended	13 April ± 10 days	16 September ± 16 days
Duration	46 ± 15 days	23 ± 11 days

Dates are the means ± standard deviation over fifteen years, 1969 – 83.

Hand-pollination was carried out each year during the main flowering season but was not carried out during the secondary flowering seasons of 1969, 1971, 1977, 1980, 1982 and 1983.

TABLE 4. HAND-POLLINATIONS[a] CARRIED OUT AT THE RUBBER RESEARCH INSTITUTE OF MALAYSIA DURING THE MAIN AND SECONDARY FLOWERING SEASONS

Year	No. of crosses		No. of pollinations		Fruit-set (%)	
	I	II	I	II	I	II
1971	19	n.a.	27 265	n.a.	2.6	n.a.
1972	17	9	40 953	10 365	4.4	7.6
1973	22	6	35 021	8 996	2.9	12.6
1974	19	5	24 693	9 018	3.0	14.7
1975	10	11	30 431	14 470	5.5	9.1
1976	15	6	24 841	8 065	2.9	4.9
1977	14	n.a.	25 122	n.a.	3.4	n.a.
1978	17	2	13 358	2 393	1.6	1.0
1979	14	5	16 531	1 966	1.2	7.0
1980	27	n.a.	35 893	n.a.	1.9	n.a.
Mean	17.4	6.3	27 411	7 896	2.94	8.13
t_{15}	5.483***		5.510***		2.642*	

[a]Inter-specific crosses, self-crosses and crosses using irradiated material excluded

I = Main flowering season

II = Secondary flowering season

n.a. = Pollination not attempted

*$P<0.05$ *** $P<0.001$

Fruit-set data were logarithm transformed to equalise variances for the t-test.

Daily meteorological readings (rainfall, relative humidity at 1000 h, maximum temperature, solar radiation and evaporation) were averaged over ten years (1971 - 80) for each main and secondary flowering season. For this purpose, readings between the first and last days of hand-pollination for each flowering season were used. As shown in *Table 5,* evaporation, solar radiation and maximum temperature were significantly lower during the secondary flowering season compared with the main season. Mean evaporation and solar radiation each recorded a decrease of about 10% in the secondary season while a smaller decrease of 4% was observed for maximum temperature. It is not possible to determine from the data the effective contribution of each of the three meteorological factors to the seasonal differences on fruit-set. Nevertheless, a broad assessment could be made based on the models constructed for the variation in daily fruit-set success of the cross PB 5/51 × RRIM 703. As noted from the multiple regression analysis above, fruit-set success was negatively correlated with evaporation *(Day 0)* and positively correlated with maximum temperature *(Day 0* and *Day 2)* and relative humidity *(Day -1)*. As the mean daily maximum temperature *decreased* in the secondary flowering season compared with the main season, this variable could not have contributed favourably to the higher fruit-set observed in the secondary season. The remaining two variables, solar radiation and evaporation, could be expected to be correlated positively with each other. As the foregoing analysis of fruit-set success of the cross PB 5/51 × RRIM 703 has indicated that evaporation is the more important variable of the two, it is pertinent to focus on the relationship between seasonal fruit-set success and seasonal evaporation. The simple regression between fruit-set

TABLE 5. METEOROLOGICAL CONDITIONS DURING THE MAIN AND SECONDARY FLOWERING SEASONS

Year	Relative humidity[a] (%)		Maximum temperature (°C)		Rainfall (mm day^{-1})		Proportion of rainy days		Solar radiation (g cal^{-1} cm^{-2} day^{-1})		Evaporation (mm day^{-1})	
	I	II	I	II	I	II	I	II	I	II	I	II
1971	76.1	n.a.	32.5	n.a.	12.2	n.a.	0.7	n.a.	502	n.a.	5.3	n.a
1972	76.8	79.4	32.7	31.8	3.4	2.0	0.3	0.5	503	458	5.8	5.2
1973	78.9	83.1	33.0	31.4	4.1	6.0	0.6	0.5	495	454	5.1	4.9
1974	73.2	77.7	32.9	31.9	4.8	10.9	0.5	0.4	538	461	5.7	5.3
1975	76.5	77.0	32.7	31.8	6.5	4.2	0.5	0.5	523	476	5.4	5.4
1976	79.1	79.6	32.6	31.7	9.5	6.5	0.7	0.5	503	461	5.5	4.4
1977	73.8	n.a.	33.6	n.a.	4.8	n.a.	0.5	n.a.	551	n.a.	6.1	n.a.
1978	82.1	81.9	33.3	32.3	6.2	2.5	0.5	0.4	533	495	5.2	4.8
1979	81.5	77.1	33.6	31.9	5 .2	7.3	0.4	0.4	551	472	5.8	5.0
1980	78.9	n.a.	33.1	n.a.	6.5	n.a.	0.6	n.a.	515	n.a.	4.8	n.a.
Mean	77.7	79.4	33.0	31.8	6.3	5.6	0.53	0.46	522	468	5.47	5.00
II as % of I	102		96		89		87		90		91	
t_{15}	1.265 N.S		6.761***		0.495 N.S		1.440 N.S		5.831***		2.573*	

[a]Readings at 1000 h

n.a. = Hand-pollination not attempted

I = Main flowering season

II = Secondary flowering season

* P<0.05 *** P<0.001 N.S. = Not significant

Readings are the means of daily recordings taken between the first and last days of hand-pollination for each season.

and evaporation for the cross PB 5/51 × RRIM 703 was given as:

$$\text{Fruit-set} = -2.862 \text{ Evaporation (Day 0)} + 27.60$$

$$r = -0.606 \ (P<0.05)$$

(In this instance, percentage fruit-set is not logarithm transformed as was done in the earlier analysis because linear proportionality which is desired in the ensuing argument would be lost on back-transformation.) Thus, for every millimetre increment in daily evaporation, there was, on the average, a decrease of 2.86% fruit-set success. Applying this relationship to the overall seasonal fruit-set, the 0.53 mm average difference in daily evaporation between the main and secondary flowering seasons would hence explain 1.5% difference in fruit-set success. As the seasonal difference in fruit-set is in the region of 5%, it would appear that, at most, evaporation differences can explain only a small part of the seasonal discrepancy in fruit-set. This inference holds when the relationship between evaporation and fruit-set established for the particular cross studied (PB 5/51 × RRIM 703) is assumed to be applicable to fruit-set of clones in general. Such an assumption may or may not be valid, but would, in any case, permit at least a rough assessment of the extent by which evaporation differences can influence seasonal fruit-set success.

DISCUSSION

The multiple regression analysis indicated that for the cross PB 5/51 × RRIM 703 of 1975, four meteorological variables: evaporation *(Day 0)*, relative humidity *(Day -1)*, maximum temperature *(Day 0)* and maximum temperature *(Day 2)* contributed to fruit-set success, jointly 'explaining' 94% of its variation. The multiple correlation should nonetheless be regarded with some degree of circumspection in view of the limited data (fruit-set from only twelve days of hand-pollination) on which the computation was based. It was for this reason that a confirmatory study was subsequently carried out, using a non-parametric method, involving a wider range of crosses, years of hand-pollination and with representations from both flowering seasons. The findings in the latter study corroborated those of the regression analysis in respect of the effects of evaporation rate *(Day 0)* and relative humidity *(Day -1)*. Whereas in the multiple regression analysis the maximum temperature *(Day 0* and *Day 2)* had been seen also to influence fruit-set significantly, it was not found to be significant in the non-parametric analysis. This was not unexpected given the existence of inter-correlations between the variables in the regression model. In the stepwise multiple regression analysis itself *(Table 1)*, the effects of maximum temperature were not apparent until the third and fourth steps of the analysis, only after variation in evaporation *(Day 0)* and relative humidity *(Day -1)* had been held constant. The effects of maximum temperature might not therefore be readily observed in the non-parametric analysis where its relationship with fruit-set success was being examined in isolation, without allowance having been made for interactions with other variables.

While some of the major meteorological factors have been examined in this study, there are obviously numerous other aspects of the weather that have not been accommodated. This should be borne in mind in any overview of climatic influences on fruit-set. For example, only meteorological conditions around the time of hand-pollination were analysed whereas conditions some considerable period before or after hand-pollination could conceivably have been as important. The effect of rain on fruit-set is not easily interpretable from the available data. Hand-pollination was abandoned whenever it rained, or threatened to rain or when the flowers were wet from the previous night's rain. Thus, some of the days arguably the most likely to be adversely affected by rain did not feature at all in the analyses.

Differences in fruit-set between the main and secondary flowering seasons in relation to weather should be viewed cautiously and the aim of this aspect of study should be kept in sight. Essentially, it was to estimate, very broadly, the possible extent to which meteorological factors could contribute to the seasonal difference in fruit-set success. It is not implied that the association between seasonal fruit-set success and climatic conditions is necessarily causal. Being a deciduous tree, *Hevea* can be expected to undergo considerable physiological changes with season, many of these having a bearing on fruit-set. Hence, it is possible that the apparent association between seasonal fruiting and evaporation might be indirect or even coincidental. In any case, as pointed out, seasonal differences in evaporation rates have at most, only a minor influence on the seasonal differences in fruit-set and other factors (e.g. pathogens) could be expected to play more important roles.

The relationship between climatic factors and fruit-set in the present study is valid only over the range of fruit-set figures encountered in the course of the study and should not be extrapolated. Among the crosses considered in this study, fruit-set, even on the most successful day, was only 27%. Hence, there would have been at least 73% of hand-pollinations that failed and could not be covered by the analyses. As such, the principal problem of low fruit-set in *Hevea* is not addressed in this study. Nevertheless, the results obtained might form a basis for attempts to optimise fruit-set success within the range normally encountered by simulating selected environmental conditions. Obviously, general climatic conditions are not readily manipulated in the field but it is conceivable that the micro-climate to which selected flowers are subjected might be regulated to some extent. For example, male flowers could be harvested and brought back to the laboratory for a specific environmental pre-treatment. Prior to this, however, there is need to establish whether it is the male flower or female flower that is predisposed to the influence of meteorological conditions.

ACKNOWLEDGEMENT

The authors are grateful to Dr Leong Wing for supplying the meteorological data used in this study. Thanks are due to Mr Eric Chua who supervised the hand-pollinations and Puan Fatimah Kamilah Omar who assisted in the data analyses. The authors also thank Dr P.K. Yoon and Dr Zahar Samsuddin for their valuable comments and criticisms on the manuscript.

REFERENCES

1. WYCHERLEY, P.R. (1971) *Hevea* Seed (Part II). *Planter, Kuala Lumpur,* 47, 345.
2. ROSS, J.M. (1961) Observations on the 1959 Hand Pollination Programme at the RRIM. *Proc. nat. Rubb. Res. Conf. Kuala Lumpur 1960,* 392.
3. YEANG, H.Y. AND GHANDIMATHI, H. (1984) Factors Influencing Fruit-set in *Hevea* Following Hand-pollination. *'Compte-Rendu Collogue Exploitation-Physiologie et Amelioration de l'*Hevea'. L'Institute de Recherches sur le Caoutchouc, Paris & Montpellier. I.S.B.N. 2-901317-00-6, 401.