

FLOWERING, POLLINATION AND POD SETTING IN CACAO

PN RAVINDRAN

*CPCRI Regional Station
Vittal-574 243, Karnataka*

ABSTRACT

This study was undertaken in 8-year old 'Forastero' cocoa (*Theobroma cacao*) mix-planted with arecanut palms (*Areca catechu*) of the same age. The crop is irrigated during the dry months (December-May). The observations on flowering and pod setting were recorded in ten trees, and in each tree, observations were limited to the main trunk, and the figures later transformed to give flower production and fruit set per meter of the main trunk. Natural pollination was studied by randomly collecting 25 flowers daily (in the afternoon) and observing for the presence of pollen grains under the microscope. Efficiency of various pollination methods were studied using fully cross compatible trees. Monthly flower production and fruit setting varied from tree to tree. The peak period of flowering was in May, and the peak period of fruit setting was in March and October. Fruit set was generally more during the dry months from December to June, and very low or absent during July-September. The mean annual fruit set was only 3.0% and out of this only about one fourth reached maturity.

Pollination study showed that 28.2% flowers got pollinated under field conditions, while only about 8% of this was successfully pollinated (i.e. having sufficient number of pollen grains for fertilizing majority of ovules present in the ovary). The maximum successful pollination was in March (11%) and the minimum was in December (4.4%). Pollination trials indicated that pollinating on the style gave maximum setting (82%), while pollinating on the stigma alone gave 66.5% setting. The results are discussed in the light of available information.

INTRODUCTION

In India cocoa growing is restricted to parts of Tamil Nadu, Kerala and Karnataka. Towards the south Tamilnadu the annual rainfall is less (about 2050 mm) but better distributed, while towards the north of Kerala and Karnataka the rainfall is about 3800 mm,

and is mainly limited to the South-West monsoon, active from June to October. In most of the areas cocoa is grown under irrigation, mainly as a mixed crop coconut or arecanut gardens. The present studies were undertaken with irrigated cocoa, mixed planted with arecanut at the experimental farm of CPCRI Regional Station, Vittal. The climate here is representative of that of the west coast of India, the mean annual rainfall being 3800 mm which falls mainly during the monsoon from June to October, the remaining months (December-June) being dry. Since cocoa is mainly an irrigated crop in this area, this study was taken up with a view to assess the nature of flowering, pollination and pod-setting under the conditions existing in the west coast of India on which there is no literature at present.

MATERIALS AND METHODS

The study was undertaken in 8-year old upper Amazon type of cocoa interplanted in arecanut garden of the same age. The cocoa population consisted of 47 genotypes, all of them introduced from Malaysia, planted randomly in an Areca garden. The crop was irrigated during the drought months (December-May). The study was conducted for one full year to get an idea on the pattern of flowering, pollination and pod setting.

Observations were recorded for ten randomly selected trees which were located inside the cocoa garden. In each tree half meter length of the trunk was marked, and flowering and fruit setting were recorded daily for one year. The flowers were counted in the morning when the day's flowers and previous day's flowers were easily distinguishable. Pod setting was counted immediately after the ovary started developing. The developing fruits were all marked by means of a pin and a piece of coloured cloth.

In order to study the extent of natural pollination under the existing field conditions, twenty-five flowers collected at random from five trees were observed under a microscope and pollen grains on the stigmas and styles were counted. Those stigmas and styles with 40 or more pollen grains were counted as successfully pollinated, those with 30-40 pollen grains as less successfully, and those with less than 30 pollen as unsuccessfully pollinated. The scale

was fixed because it was found that the pods contain on an average 20-30 seeds, and that the pollen fertility of cocoa varies from 80-90% (as assessed from pollen stainability). When successfully pollinated, always large groups of pollen grains were found on the style or stigma. On an average 200-300 flowers were observed every month.

The efficiency of different pollination methods was studied by conducting two pollination trials. For this, trees which were previously established as cross compatible, were used. Five treatments were included in the trial: Pollinating on (1) the stigma only, (2) style only, (3) base of the style, (4) stigma and style and (5) stigma, style and base of the style. The pollinations were carried out between 10 and 12 h by the usual method of collecting the dehisced anthers and rubbing on the stigma, style or the base of the style. In all cases the flowers were protected from pollen contamination by isolating them in conical hoods made of fine nylon blotting cloth, kept fixed on to stems by means of drawing board pins.

RESULTS AND DISCUSSION

Considerable variation was noticed in flower production among the trees (Table 1). In six trees, the peak flowering was in May, in two trees it was in February, in one each the peak period was in July and December. The annual flower production varied among trees from 168/m to 2358/m of the stem. Flower production was heavy from December to May, and then decreased, reaching minimum during August-September. In general there were two peak periods of flowering one in April-June and the other in December-February.

In unirrigated cocoa the flowering pattern may be quite different. Here flower production usually is not distributed for the entire period, but is limited usually to two seasons a year. In countries like Ghana and Nigeria where the rainfall is more evenly spaced, flowering was found throughout the year, though varietal variations existed (Amponsah, 1973, 1975, 1976). As far as India is concerned there is no information on the comparative performance of cocoa under irrigated and unirrigated conditions;

Table 1. *Monthly flower production in cacao (CPCRI Regional Station).

Tree No.	July	August	Septem-ber	October	Novem-ber	Decem-ber	January	February	March	April	May	June	Total
1	34	..	..	6	36	66	8	20	14	44	244	128	600
2	84	14	66	136	70	82	18	28	58	236	504	84	1080
3	140	150	136	280	310	324	6	38	52	170	416	54	2076
4	160	..	..	..	22	14	4	46	172	142	268	45	874
5	90	10	12	18	76	216	54	194	108	18	176	38	1010
6	188	..	14	24	128	178	124	162	78	26	162	130	1214
7	50	4	24	6	82	80	44	88	68	50	248	56	803
8	342	6	..	..	66	490	102	838	76	74	254	110	2358
9	48	..	20	14	46	68	104	202	86	44	144	46	822
10	..	..	..	..	22	14	26	4	18	10	52	22	168
Monthly mean	114	18	27	48	86	153	49	162	73	81	247	71	

*Values per meter of the main stem.

though it is reported that the performance of cocoa under rainfed condition is extremely poor. In a different population consisting of ICS and ICS \times Criollo hybrids, the mean fruit set under rainfed condition was found to be only 11.4 pods per tree per year (Anonymous, 1976).

Table 2 gives the data on fruit setting. All the flowers that started developing were counted as 'set' irrespective of the fact whether they reach maturity or not. Setting percentage was high in March, June and October while in August-September no setting was recorded. In general setting was poor during the rainy season (July-September). Fruit setting seems to be inversely related to flower production. Trees with high flower production gave low fruit set, while trees with low flower production gave better fruit set. The cause of this is not clear. The profuse flowering is more a wastage of energy on the part of the tree than an advantage. Out of the fruits set, only less than one-fourth reaches maturity, and the rest either wilt at cherule stage or otherwise get damaged later.

Table 3 shows the extent of natural pollination in the experimental area. The data show that the successful pollination (leading to fertilisation and subsequent development of ovary) was only 8%, though total pollinated flowers (i.e. flowers on which pollen grains were noted on the stigma or style) were 28.2%. The percentage of successfully pollinated stigmas and styles varied from day to day and monthly mean show no definite relationship. This only shows that the behaviour of the pollinating insects is erratic. The maximum successful pollinations were in March (11.0%) and the minimum in December (4.4%). The difference observed between successful pollinations and pod setting might be due to various reasons, such as incompatible pollinations, influence of climatological factors, etc.

Considerable variation in flowering and fruit setting patterns of various genotypes was reported from Nigeria and Ghana (Anonymous, 1967, Edwards, 1973 a and b; Amponsah, 1973, 1975, 1976). It was also reported that such variation existed in the activity of the pollinating insects and the percentage of flowers pollinated during different months. The highest pollination rate was reported in August-September (65%) and the lowest in February (11%)

Table 2. *Fruit setting in cacao (CPCRI Regional Station, Viital).

Tree No.	July	August	Septem-ber	October	Novem-ber	Decem-ber	January	February	March	April	May	June	Total % setting
1	..	..	..	..	2	6	2	2	4	..	6	4	26
2	6	..	..	12	12	4	..	2	2	2	6	2	48
3	..	..	..	12	6	16	..	12	2	2	2	..	52
4	..	..	..	..	..	6	..	..	2	2	10	2	22
5	..	..	..	..	..	..	..	12	2	2	6	4	26
6	..	..	..	4	4	8	..	4	8	4	8	6	42
7	..	..	..	..	6	6	..	2	4	4	2	8	32
8	..	..	..	..	..	10	..	6	10	4	2	8	40
9	..	..	..	..	2	2	..	8	6	2	..	4	24
10	..	..	..	..	..	4	10	..	4	..	..	2	20
Total	6	0	0	28	32	62	12	48	44	22	42	40	336
% setting	0.5	0	0	5.8	3.7	4.1	2.4	3.0	6.0	2.4	1.7	5.3	3.0

*per meter of the main stem.

Table 3. Natural pollination of cacao flowers (CPCRI Regional Station, Vital).

Month	No. of stigmas/ styles observed	No. of stigmas/styles with pollen				Total pollinated		Successfully polli- nated %
		40 (1)	30-40 (2)	30 (3)	No. pollen (4)	%	%	
April	200	19	4	31	146	27.0	9.5	
May	300	24	9	42	225	25.0	8.0	
June	300	20	6	18	256	14.6	6.6	
July	300	15	1	45	239	20.3	5.0	
August	250	26	5	46	173	30.8	10.4	
September	250	14	3	35	198	20.8	5.6	
October	250	15	8	30	197	20.8	6.0	
November	300	24	6	72	198	34.0	8.0	
December	250	22	7	68	153	38.8	8.8	
January	250	19	9	44	178	28.8	7.6	
February	250	23	13	51	163	34.8	9.2	
March	300	33	17	59	191	36.3	11.0	
Total	3200	254	83	565	2298	28.0		
%		8.0			72.0			

Table 4. Efficiency of different pollination methods in Cacao.

Method of pollination	Exp. I		Exp. II		Mean setting %
	Flowers pollinated	% setting	Flowers pollinated	% setting	
1. On stigma	100	58	120	75.0	66.5
2. On style	100	74	120	90.0	82.0
3. On base of the style	100	42	120	35.8	38.0
4. On stigma and the style	100	65	120	77.5	71.3
5. On stigma, style and base of the style	100	66	120	80.0	73.0

SE = 6.8; C.V. = 20%, LSD = 12.2

(Anonymous 1967). It is interesting to compare this result with the present findings. The highest pollination rate observed here was 38.8% in December and the lowest was 14.6% in June. But in both cases the percentage of successfully pollinated flowers leading to fruit set, was considerably low. Edwards (1973 a and b) found that in Ghana the highest setting following natural pollination differed among clones, though generally the setting was high in November-December and low in March-April. Amponsah (1973; 1975) observed that in two consecutive years the highest fruit set was in July (14.7% and 20.5%), the mean annual setting being 7.9% and 9.2% respectively. The lowest setting in the two countries might be due to differences in the activity and population of the pollinating insects, and the compatibility status of the plant population. The self-compatibility of the Amelnado population might be to a great extent responsible for the higher fruit set in Ghana.

A comparative study of the efficiency of some pollination methods showed that pollinating on the style gave the maximum fruit set and this was significantly more than the setting obtained by pollinating on the stigma only (Table 4). Pollinating on the base of the style gave very poor fruit set (38.0%). The results indicate that the stylar tissue has all the prerequisites for pollen germination and that the tubes need travel only a shorter distance than the tubes coming from the stigma. This may be the reason for the better fruit set in the case of the flowers pollinated on the style. But at the same time pollinating on the base of the style is not advantageous, because the conditions might not be conducive as to stimulate growth and that the pollen tubes need penetrate a much thicker tissue before reaching the ovules. When hybrid seed production through manual pollination is resorted to, pollinating on the style can be profitably employed for increasing fruit setting.

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