

The Morphology and Biology of the Cashew Flower *Anacardium occidentale* L.

II. ANTHESIS, DEHISCENCE, RECEPTIVITY OF STIGMA, POLLINATION, FRUIT-SET AND FRUIT DEVELOPMENT

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In an earlier paper (1965), the authors reported the results of their investigation on the flowering habit, flowering season, floral morphology and sex ratio in Cashew. Observations on anthesis, dehiscence, receptivity of stigma, pollination, fruit-set and fruit development are summarised and presented in this paper.

Observations

1. *Anthesis*

The flowers opening on five panicles each on the sunny side and shady side of a tree during one hour intervals from 7 A. M. to 2 P. M. and two hour intervals from 2 P. M. to 6 P. M. were counted and recorded. Separate data were collected in respect of staminate flowers and perfect flowers during the period 28-11-1961 to 7-12-1961. The data are presented in Table 1.

It may be seen from the above Table that nearly half of the staminate flowers opened before 7A. M. and the opening of over 95 percent was completed before 11 A. M. There was practically no anthesis of staminate flowers after 2 P. M. In the case of perfect flowers, the peak period of anthesis was between 10 A. M.

and 12 Noon. The opening of perfect flowers on the shady side was a little later than that on the sunny side.

2. *Dehiscence of anthers*

The anthers dehisce by means of longitudinal splits of the two anther lobes exposing the pollen grains which appear to be bluish grey in colour immediately after dehiscence. When they become dry within a few minutes they turn brown. There was no dehiscence of anthers before 8 A. M. In order to study the rate of dehiscence of anthers, fifty flowers each on the sunny and shady sides of a tree were marked at 8 A. M. The number of marked flowers with dehisced anthers were recorded at half hour intervals till 12 Noon and at one hour intervals thereafter. These observations were made on five days from 29-11-1961. The data are given in Table II.

It is apparent from Table II that the peak period of dehiscence of anthers was between 9.30 A. M., and 11 . 30 A. M. Till about 10 . 30 A. M., the rate of dehiscence was slightly higher on the sunny side as compared to that on the shady side of

TABLE I
Flowers opened at different hours

Type of flower	Percent of flowers opened									
	Before 7 A. M.	7-8 A.M.	8-9 A.M.	9-10 A.M.	10-11 A.M.	11-12 A.M.	12-1 P.M.	1-2 P.M.	2-4 P.M.	4-6 P.M.
<i>Staminate</i>										
Sunny side	42.4	18.0	11.6	16.0	7.3	2.8	1.5	0.3	0.1	—
Shady side	45.8	17.6	9.7	14.0	8.3	2.6	1.4	0.6	—	—
<i>Perfect</i>										
Sunny side	4.2	9.6	—	2.8	50.8	28.6	4.0	—	—	—
Shady side	5.0	3.7	1.4	6.0	20.7	56.0	7.2	—	—	—

TABLE II

Rate of dehiscence of anthers in cashew flower

Position of flowers on tree	Mean percent of flowers which had their anthers dehisced between												
	8.00 8.30 A.M.	8.30 9.00 A.M.	9.00 9.30 A.M.	9.30 10.00 A.M.	10.00 10.30 A.M.	10.30 11.00 A.M.	11.00 11.30 A.M.	11.30 12.00 A.M.	12.00 1.00 P.M.	1.00 2.00 P.M.	2.00 3.00 P.M.	3.00 4.00 P.M.	4.00 6.00 P.M.
Sunny side	..	5.2	13.6	24.4	26.4	18.0	8.8	2.0	0.4	0.4	0.4	0.4	—
Shady side	..	2.4	7.2	22.4	18.0	23.6	13.2	8.8	1.2	0.4	2.0	08	—

the tree. It was also observed that on days of normal sunny weather, dehiscence was practically over before 1 P. M. On 30-11-1961 the weather was very cloudy throughout the day and the dehiscence commenced only after 10 A. M. and continued till 4 P. M.

3. Receptivity of stigma

Receptivity of stigma was studied by carrying out controlled pollinations at specified times before and after anthesis and finding out the extent of fruit-set in

each case. Emasculated buds and flowers under the different age groups on selected panicles were bagged and pollinated at specified times and the fruit-set resulting therefrom was recorded. The data are presented in Table III.

It appears from the data in the above Table that stigma of the cashew flower was receptive even one day before anthesis and continued to be so for about 48 hours after anthesis. However, the optimum period seemed to be soon after anthesis, as

TABLE III

Period of receptivity of stigma in cashew flowers

Stigmatal age group	No. of flowers	No. which set	Percent of fruit set
One day before anthesis	11	2	18.2
At 12. N on the day of anthesis	12	9	75.0
At 3 P. M. do	60	27	45.0
One day after anthesis	14	3	21.4
Two days after anthesis	16	2	12.5
Three days after anthesis	15	Nil	Nil

indicated by the highest percentage of fruit-set when pollination was done at 12 Noon on the day of anthesis.

4. Pollination

(a) *Pollen morphology*: Soon after dehiscence, the pollen grains in a mass appeared to be bluish grey in colour; but within a few minutes, they became dry and the colour turned brown. The normal shape of the pollen grains in a dry state is

elliptic to oblong; but when moistened they assumed a round or somewhat triangular shape. When mounted in Methyl green-Glycerine Jelly, as described by Woodhouse (1935), a fairly thick exine except at the three germ pores and a thin intine are visible. Slight variation was observed in the mean size of the pollen grains collected from two trees, as may be seen from Table IV.

TABLE IV

Size of pollen grains in microns

Tree No.	Mean size of pollen grains			Range of variation in diameter of grains in M. G. G. J.
	In methyl green Glycerine Jelly (Diameter)	In Aniline oil Length	In Aniline oil Breadth	
8A	28.1	43.9	23.7	25.9—30.8
30A	26.1	35.4	24.7	22.7—29.1

(b) *Pollen viability and germination in artificial medium*: The viability of pollen grains as indicated by deep staining in acetocarmine was found to be 93.9 on an average. However, the highest germination obtained in artificial medium was only 36.2 percent. The highest germination was obtained in 30 percent sucrose solution at room temperature (28 oC).

(c) *Pollination*: The structure of the cashew flower is more conducive to cross pollination than self pollination. The developed stamen in the hermaphrodite flower is only about half in length of the style and its anther generally dehisces only late in the evening. Therefore, the chances of the stigma being pollinated by the pollen of the same flower are rather slender.

However, controlled pollination did not indicate any degree of self incompatibility in Cashew. Wind appears to be the predominant agency for pollination, as the insect visitors were found to be very few and rare. Black and red ants, the hover fly (*Musca nebulosa*) and the common bee (*Apis indica*) are the insects which were rarely found to visit the Cashew flowers.

(d) *Staminodes*: The staminodes, varying from 7-9 in number in each flower, were found to contain some normal and viable pollen grains. In order to study their role in pollination, fifty perfect flowers on five panicles were bagged after removing the developed anthers and all

staminate flowers. All the flowers failed to set fruit, indicating that staminodes alone do not generally play any part in pollination under natural conditions.

5. *Fruit-set and fruit-drop*

In about 7 days after pollination, the ovary swells and becomes visible outside the corolla cup. A large portion of the perfect flowers drop off before this stage, either due to lack of pollination or due to natural drop. In order to study the extent of fruit-set and fruit-drop in trees with high and low sex ratios, five panicles were labelled on each of the above categories of trees and data were collected on fruit-set and fruit-drop. (Table V)

TABLE V
Fruit-set and fruit-drop in Cashew

Tree No.	Panicle No.	No. of flowers		No. of flowers set fruit	No. of fruits dropped			No. of fruits matured
		Perfect	Male		A	B	C	
28	1	24	978	7	2	2	1	2
	2	73	1418	32	17	9	1	5
	3	31	950	13	5	4	1	3
	4	18	848	1]	-	-	-
	5	26	810	12	8	2	1	1
Mean per panicle		34.4		13	6.6	3.4	0.8	2.2
Percent of perfect flowers				37.8				6.4
38	1	65	595	22	11	3	1	7
	2	59	504	23	13	7	0	3
	3	58	259	24	15	6	1	2
	4	49	253	9	7	1	1	0
	5	32	282	7	6	1	0	0
Mean per panicle		52.6		17.0	10.4	3.6	0.6	2.4
Percent of perfect flowers				32.3	-	-	~	4.3

A. Fruit below 5 mm in length; B. Between 5 mm and 10 mm. C. Above 10 mm.

It is evident from Table V that the mean number of fruits set per panicle was slightly higher in the case of the tree with the higher sex ratio as compared to the tree with a low sex ratio. However, the difference was not fully reflected in the ultimate number of fruits per panicle carried to maturity. Only 4-6 per cent of the perfect flowers carried fruits to maturity. The intensity of drop was heaviest before the fruit attained a length of 5 mm.

6. Fruit development

The nut which is the true fruit in Cashew is usually pink in colour in the early stages of development. Later it turns green and ultimately when the shell hardens, it turns ash grey in colour. The nut attains the maximum size in about 5 weeks after fruit-set and as the shell begins to harden it

shrinks in size. The size of the nut varied considerably from tree to tree. The minimum average weight of nut recorded in these studies was 4.1 g and the maximum was 10.2 g. Nuts of different sizes and shapes may be seen in Fig. 1.

The pedicel which develops into the Cashew apple grows very slowly in the early stages of development of the nut; but during the last three weeks when the nut begins to shrink, the apple develops rapidly and outgrows the nut. The colour of the apple when ripe is pink, red, yellow or a mixture of these colours, to give varying shades. The size and shape of the apple vary considerably from tree to tree as may be seen from Fig. 2.

Data on the development of the nut and apple are given in Table VI and represented graphically in Fig. 3.

TABLE VI
Development of nut and apple in Cashew

Particulars	Weeks after fruit set							
	1	2	3	4	5	6	7	8
<i>Nut</i>								
Length (cm)	0.78	2.05	2.87	3.37	3.47	3.25	2.90	2.60
Per cent of max. length	22.4	59.1	82.7	97.1	100.0	93.6	83.5	74.9
Breadth (cm)	0.60	1.20	1.66	2.07	2.11	2.00	1.84	1.70
Percent of max. breadth	28.4	56.9	78.7	98.1	100.0	94.8	87.2	80.6
<i>Apple</i>								
Length (cm)	0.83	1.49	1.85	2.26	2.60	2.97	3.36	3.60
Per cent of max. length	23.7	42.6	52.9	64.6	74.3	84.9	96.0	100.0
Diameter (cm)	0.30	0.56	0.75	1.00	1.20	2.01	2.65	2.90
Per cent of max. dia.	10.3	19.3	25.8	34.8	41.4	69.3	91.4	100.0

Diameter was measured at the thickest portion.

initial set was higher in a tree with high sex ratio as compared to that in a tree with low sex ratio; but this difference was not fully reflected in the ultimate number of mature fruits obtained. This was due to the higher intensity of fruit drop in the former as compared to the latter. However, a comparison of sex ratio and yield of different trees (as reported in the earlier part of this paper) suggested a positive correlation between these characters. Rao and Vazir Hassan (1957) stated that there were indications of a better fruit set when the distance between the stigma and the anther was short. The suggestion seems to be that there are better chances of pollination in such a flower. But the fact that the anther of the perfect flower is always far below the stigma and dehisces only late in the evening indicates that the chances of pollination from the anther of the same flower are rather remote.

Observations on the development of the nut and the apple are in conformity with those of Rao and Vazir Hassan (1957).

Summary

Studies were carried out on anthesis, dehiscence of anthers, receptivity of stigma, pollination, fruit-set and fruit development in Cashew. Staminate flowers were found to open very early in the morning and it continued till about 2 P. M. Over 80 per cent of the perfect flowers opened between 10 A. M. and 12 Noon. The peak period of dehiscence of anthers was from 9.30 A. M. to 11.30 A. M. and the rate of dehiscence was slightly higher on the sunny side of the tree as compared to that on the shady side. The stigma was found to be receptive 24 hours before anthesis and continued to be so for about 48 hours after anthesis, the optimum period being round about 12 Noon on the day of anthesis. Morphological features of pollen grains were similar in

all trees and 94 per cent of the grains were viable. In artificial medium, the highest germination obtained was only 36.2 per cent in 30 per cent sucrose solution at room temperature (28°C). Staminodes did not play any significant role in pollination under natural conditions, even though they contained some viable pollen grains. Only 4-6 per cent of the perfect flowers were carried to maturity. There was reduction in the size of the nut to the extent of about 25 per cent after the shell began to harden. It took 54 days on an average from fruit-set to full ripening of the fruit.

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It is apparent from Table VI and Fig. 3 that the rate of growth of nut was rapid during the first three weeks after fruit-set when there was very little increase in the diameter of the apple. The nut began to shrink from the fifth week onwards and at the time of maturity, the size was only about 75 per cent of the maximum size attained. It may also be seen from Fig. 3 that the thickening of the apple was very rapid during the last three weeks before full ripening.

It took about 47 days from fruit set to the stage when the nuts turned grey and about 54 days for the full ripening of the fruit.

Discussion

Aiyadurai and Koyamu (1957) have reported that staminate flowers open between 9 A. M. and 11 A. M. while bisexual flowers open between 2 P. M. and 4 P. M. In the present study, however, it was found that nearly half of the staminate flowers opened very early in the morning before 7 A. M. and the anthesis continued till about 2 P. M. In the case of perfect flowers, over 80 per cent were found to open between 10 A. M. and 12 Noon. According to Rao and Vazir Hassan (1957), the peak period of anthesis was between 9 A. M. and 11 A.M., the hermaphrodite flowers opening between 9 A. M. and 1 P. M. The variation in these observations may, perhaps, be attributed to the different climatic and other environmental conditions under which these studies were undertaken.

The peak period of dehiscence of anthers was found to be between 9-30 A. M. and 11-30 A. M. which conforms to the observations of Rao and Vazir Hassan (1957). It was also observed in the present study that the rate of dehiscence was slightly higher in the early hours on the sunny side

of the tree as compared to that on the shady side.

Rao and Vazir Hassan (1957) observed that the stigma remained receptive only on the day of anthesis. The present study has revealed that the stigma was receptive even one day before anthesis and continued to be so for about 48 hours after anthesis, at least in some flowers. It has, however, to be mentioned that the observation in the present study regarding the receptivity of stigma before anthesis is not conclusive. It was quite possible that stigma was not receptive when the pollination was done one day prior to anthesis; but the pollen grains which remained viable for some time germinated when the stigma became receptive at a later time. The optimum period of receptivity was found to be soon after anthesis round about 12 Noon.

The morphological features of pollen grains were similar in all the trees even though there were slight variations in the mean size of pollen grains, collected from different trees. About 94 per cent of the pollen grains were found to be viable as indicated by the acetocarmine test. However, the highest percentage of germination obtained in artificial medium was only 36.2 at room temperature (28°C). It is possible that under controlled conditions of temperature, higher percentage of germination can be obtained.

The present studies did not indicate any degree of self or cross incompatibility in Cashew flowers. The structure of the flower would seem to favour cross pollination and wind appeared to be the main pollinating agency.

It was found that only 4-6 per cent of the perfect flowers were carried to maturity under natural conditions. This is generally in agreement with the observations of Rao and Vazir Hassan (1957). The