# On factors influencing fruit-set and sterility in arecanut (Areca catechu Linn.):

## I. Studies on Pollen grains.

V. RAGHAVAN & H. K. BARUAH,
Department of Botany,
Gauhati University,
Gauhati, India.

### INTRODUCTION.

The arecanut (*Areca catechu* Linn., Palmae) which is one of the most important of tropical fruits as a masticatory is cultivated in the hot damp regions of Asia and the Malayan Islands. In india arecanuts are grown extensively in Assam, Bengal, Bombay, Madras and the West Coast. Many different types of arecanut palms have been distinguished on the basis of the size of the fruits, majority being included in the single species, *A. catechu* Linn. However, no comprehensive investigation on the different aspects of the life history of this plant has been made except by Beccari (1919), Sands (1926), Milsum (1938) and Nambiar (1949) on the morphology and floral structure.

The plants are monœcious, male and female flowers occurring in the same spadix. A full grown spadix of arecanut produces on an average of about 2000 – 3000 male flowers and 250 – 550 female flowers, the former constituting the panicle of the spadix and the latter occupying the basal region. It is generally observed that all the female flowers that are borne on the spadix do not set fruits, a considerable majority of them falling off in the premature stages. The extent of sterility in arecanuts caused by such flower fall in the different plantations in Assam has been estimated to be between 34·5 – 54·3%. As the extent of sterility is high, it has been considered necessary to investigate the causes of sterility and fruit formation in the plant. The present investigation is based on observations made during two consecutive seasons in different plantations.

### MATERIALS AND METHODS.

The different types of arecanuts occuring have been broadly separated into five groups based on the size of the fruits: (i) Big Oblong (ii) Big Round (iii) Small Oblong (iv) Long Fruits and (v) Base Round fruits. There are many variations in size in between the different types; borderline types are also not uncommonly found. Hence, this delimitation, though arbitrary, has been adopted as a working system for the following investigations.

### EXPERIMENTAL.

*Fruit-set and Sterility.* Estimates were made on the fruit-set and sterility in the different palms on the basis of the type of fruit borne by them. The number of female flowers generally produced on the spadix and the number of fruits usually borne in the bunch were counted to determine the extent of fruit-set and sterility in each instance (Table I); figures for each type are based on the averages of at least 20 bunches. The trees in the plantations are marked. The period intervening between flowers that have been observed and the fruits that have been formed in 5–7 months, was noted to observe the trees concerned.

TABLE I.

Extent of Fruit-set and Sterility in the different types of Arecanuts.

| Locality. | Type. | No. of female flowers. | No. of fruits. | Extent of fruit-set. | Extent of sterility. |
|---|---|---|---|---|---|
| Cherrapunji. | Big Oblong | 446 | 220 | 49·3% | 50·7% |
| | Small Oblong | 503 | 278 | 55·2 | 44·8 |
| Dawki. | Big Oblong | 460 | 237 | 51·5 | 48·5 |
| | Big Round | 452 | 228 | 50·4 | 49·6 |
| | Small Oblong | 419 | 252 | 60·1 | 39·9 |
| Gauhati. | Big Oblong | 502 | 260 | 51:7 | 48·3 |
| | Big Round | 422 | 227 | 53·7 | 46·3 |
| | Small Oblong | 488 | 289 | 59·2 | 40·8 |
| Jorhat. | Big Oblong | 394 | 192 | 48·7 | 51·3 |
| | Base Round | 469 | 282 | 60·1 | 39·9 |
| | Long Fruits | 420 | 252 | 60·4 | 39·6 |
| | Small Oblong | 407 | 249 | 60·1 | 38·9 |
| Nowgong. | Big Oblong | 350 | 160 | 45·7 | 54·3 |
| | Big Round | 428 | 221 | 51·6 | 48·4 |
| | Small Oblong | 406 | 266 | 65·5 | 34·5 |
| Palasbari. | Big Oblong | 480 | 245 | 51·0 | 49·0 |
| | Big Round | 468 | 234 | 50·0 | 50·0 |
| | Small Oblong | 492 | 270 | 54·8 | 45·2 |
| Sibsagar. | Big Oblong | 522 | 287 | 54·9 | 45·1 |

It will be seen from Table I that :

(i) fruit-set varies from 45·7 to 65·5% of the total number of female flowers produced ;

(ii) flower fall appears to be related to the size of the fruits, the bigger sized fruits showing a higher extent of sterility ;

(iii) in plants bearing small types of fruits sterility was comparatively low.

In order to investigate the causes for loss in fruit-set in relation to the number of female flowers present, the pollen grains of the different types were examined to determine if sterility is associated with the presence and behaviour of the male flowers. Wodehouse (1935), Erdtman (1954 a, b) and others have stressed the importance of the morphological characters of the pollen grains in taxonomy, while Maheswari (1950) has referred to the literature on the pollen in relation to fruit set in plants.

Inflorescences with the male flowers of the different types were collected from various localities at Gauhati. Fresh panicles were brought to the laboratory in the mornings and pollen preparations were made in methyl-green glycerine jelly according to Wodehouse (1935). Preparations of the two types from Jorhat were made in the field itself and the slides were subsequently examined in the laboratory. Pollen grains of the five types were investigated; types were collected from different plantations for comparison of variations in size. The measurements were made by an ocular micrometer and the results were recorded.

The mature pollen grains in all types show a similar morphology in having a closely pitted reticulate exine a thin hyaline intine and a sharply defined oval furrow oriented parallel to the polar axis containing a small germ pore in the centre. The grains conform to the monocolpate type of Wodehouse or monosulcate of Erdtman. The fertile grains were more or less spherical, but the sterile grains varied between ellipsoid to sharply defined oval structures. The frequency of occurrence of giant grains was practically nil The sterile, crumbled or empty grains were of the same size as the fertile ones, but they could easily be distinguished by staining reactions with methylgreen glycerine jelly. There were some variations in size between the grains of the different types and of the same types collected from different localities, but the range was not appreciable. The variations in size of the fertile and sterile grains and the extent of sterile grains in the types emamined are given in Table II.

TABLE II.

Variations in size of the fertile and sterile grains and the percentages of the sterile grains in the different types.

| Types. | Extent of sterile grains. | Fertile Grains. | | Sterile Grains. | |
|---|---|---|---|---|---|
| | | Size. | Average size. | Size. | Average size. |
| Big Oblong. | 23·2% | 24·0 —38·5 u | 29·5 u | 24·5—43·75 u | 30·26 u |
| Big Oblong. | 24·7 | 24·5 —49·0 | 30·9 | 24·5—33·25 | 29·003 |
| Small Oblong. | 50·4 | 26·25—45·5 | 34·22 | 17·5—49·0 | 30·11 |
| Big Round | 100·0 | — | — | 21·0—42·0 | 31·5 |
| Small Oblong. | 5·4 | 23·625-35·0 | 30·23 | 26·0—35·0 | 31·5 |
| Big Oblong. | 9·9 | 24·5 —38·5 | 29·57 | 24·5—35·0 | 31·5 |
| Big Oblong. | 61·8 | 28·0 —48·0 | 32·53 | 15·0—73·5 | 29·83 |
| Big Round. | 4·1 | 24·5 —35·0 | 29·4 | 26·25-42·0 | 30·7 |
| Big Oblong. | 3·0 | 24·5 —36·75 | 29·5 | 28·0—33·25 | 31·65 |
| Base Round. | 24·9 | 24·5 —35·0 | 30·1 | 27·2—33·0 | 30·1 |
| Long Fruits. | 22·8 | 24·0 —37·2 | 29·8 | 26·8—39·0 | 29·6 |

(the first nine types are collected locally ; last two are from Jorhat).

It is seen that the anthers of the male flowers produce fertile pollen grains in association with varying proportions of sterile or imperfect grains. The extent of sterile grains is considerably high, varying from 3·0–100·0% in the different types examined. The examination of the individual male flowers in some of the spadices also showed that the extent of sterile grains decreases in the anthers of the flowers from the proximal to the distal portion of the panicle.

*Pollination and Flower Fall.* In many plants premature flower fall is influenced to a great extent by the failure of pollination besides certain physiological factors. Fruit-set is dependent upon the normal development of the male and female reproductive units and the successful pollination of the stigmas, affecting fertilization of the ovule. The high proportion of the presence of sterile grains in arecanut has given some indication that one of the possible factors of sterility may be failure to pollinate. An attempt was, therefore, made to see if there is any defect in the normal course of events leading to fertilization and ultimate development of the fruit.

The male phase in arecanut palm begins immediately after the spadix frees itself from the spathe (Sands, 1926). The flowers commence to open indiscriminately on the spadix and this phase is continued for 2-4 weeks till all the male flowers are exhausted. At the close of the male phase, the green petals of the female flowers lengthen and change their colour to yellowish white The petals slightly open at the tips and soon after the receptive trifid stigmas are exposed for pollination. The female phase generally lasts 4-5 days and during this period the flowers remain open all through, exposing their receptive stigmatic surfaces. The surface of the stigma is constituted of a special kind of thick walled palisade cells which are closely packed in the young flowers, but becoming club shaped and elongated during maturity of the flower, leaving interspaces in between them for the reception of the pollen grains. Scrappings taken from the stigmas on consecutive days after the opening of the female flowers showed that only a small percentage of them were pollinated.

Flower fall generally extends for a period of 20-30 days after the opening of the spadix. A casual examination of random samples of fallen flowers for successive days from different plantations gave the following data regarding the different types of fallen flowers (Table III) The number of flowers in the particular groups was counted and the relative percentages were also worked out.

It appears that:—

(i) majority of the fallen flowers in the 11 samples observed are fully open with receptive stigmas.

(ii) about 7% of them were considerably old with the integument projecting outside the perianth lobes, which is probably due to the flowers being pollinated.

(iii) a small percentage of the fallen flowers were young and closed and had abscissed from the pedicels before there could be any chances of pollination. Some of the flowers, though of a similar nature were with their perianth lobes slightly open.

The flowers were further examined to find out whether they were pollinated and if pollinated, fertilized. The stigmas were examined by teasing and staining with methyl-green glycerine jelly and in some cases with lactic acid for clearing and then staining in acid fuchsin and light green. The results show that in the first and second groups pollination is not evident, whereas in the fully open flowers about 5% revealed the presence of pollen grains on the stigmas, and in the old flowers only about 40% showed the presence of pollen grains (Table IV) However, the pollen tubes were observed only in a small percentage of the flowers. It is possible that only short tubes were produced or the tubes might have distintegrated and died. It is thus clear that a large number of flowers remain unpollinated in nature and subsequently wither; this is further supported by the fact that the number of stigmatic surfaces with germinated pollen grains *in situ* was somewhat low.

TABLE III.

Number and the relative percentages of the different groups of Fallen flowers.

| No. of collections. | Total No. examined. | Closed flowers. | Slightly open flowers. | Fully open flowers. | Old flowers. |
|---|---|---|---|---|---|
| 1 | 184 | 36 (19·56%) | 13 ( 7·06%) | 118 (64·13%) | 17 ( 9·23%) |
| 2 | 85 | 4 ( 4·7% ) | 16 (18·82%) | 61 (71·76%) | 4 ( 4·7% ) |
| 3 | 191 | 13 ( 6·8% ) | 19 ( 9·94%) | 152 (79·58%) | 7 ( 3·66%) |
| 4 | 128 | — | 10 ( 7·81%) | 117 (91·4% ) | 1 ( 0·78%) |
| 5 | 89 | — | — | 80 (89·88%) | 9 (10·12%) |
| 6 | 66 | — | 2 ( 3·03%) | 61 (92·42%) | 3 ( 4·54%) |
| 7 | 144 | 5 ( 3·47%) | 28 (19·44%) | 102 (70·83%) | 9 ( 6·25%) |
| 8 | 63 | 3 ( 4·76%) | 9 (14·28%) | 42 (66·66%) | 9 (14·28%) |
| 9 | 58 | 2 ( 3·44%) | 9 (15·51%) | 45 (77·58%) | 2 ( 3·44%) |
| 10 | 111 | 3 ( 2·7% ) | 3 ( 2·7% ) | 92 (82·88%) | 13 (11·71%) |
| 11 | 88 | 3 ( 3 4% ) | 5 ( 5·68%) | 71 (80·68%) | 9 (10·22%) |

The pollinated flowers were sorted out, and examined to find out whether they were fertilized. The ovules, after carefully removing the outer fibrous integument were fixed in formalinacetic-alcohol and embedded. Sections were cut 10/15 u thick and stained in iron haematoxylin and safranin and light green. In the sections of the female gametophytes examined, the egg apparatus was disintegrating and no trace of the pollen tube of the male nucleus could also be found. It is thus evident that no fertilizations has occurred in the fallen flowers. It is possible that failure of pollen grains to successfully germinate on the stigma and produce sufficiently long tubes could be one of the reasons for the failure of fertilization.

TABLE IV.

Number of Pollinated flowers in the different Collections of fallen flowers.

| No. of col-lections. | Closed flowers. | Slightly open flowers. | Fully open flowers. | Old flowers. |
|---|---|---|---|---|
| 1 | — | — | 7 | 6 |
| 2 | — | — | 5 | 2 |
| 3 | — | — | 5 | 2 |
| 4 | — | — | 5 | – |
| 5 | — | — | 5 | 4 |
| 6 | — | — | 3 | 1 |
| 7 | — | — | 5 | 4 |
| 8 | — | — | 4 | 5 |
| 9 | — | — | 3 | – |
| 10 | — | — | 3 | 5 |
| 11 | — | — | 6 | 4 |

The cause for the failure of the germination of the pollen grains resulting in lack of fertilization has been studied in detail by determining the germination potential of the pollen grains, extent of germination and the rate of elongation of the germ tubes in the different media.

The ability of the grains to germinate *in vitro* in nutrient solutions was investigated; concentrations of sucrose, sucrosegelatin, glucose, laevulose, maltose and starch varying from 0·1 to 10·0% were tried. The water extracts of the crushed stigmas of the different types of arecanuts were also used. Germination counts were made in duplicates by the hanging drop technique and in each case more than 100 counts were made to determine the extent of germination. The average length of the tube produced was measured by an ocular micrometer. The cultures were kept at the room temperature for 3 days till the germ tubes began to die. The rate of growth of the pollen tubes was studied and certain peculiarities noted according to the nature of the medium. The extent of germination and the average length of the germ tubes during the first 24 hours of germination of the grains of Big Oblong, Big Round and Small Oblong types are given in Table V.

The formation of germ tubes was *sin qua non* for all the types investigated. The grains germinate readily in nutrient media, the percentage of germination depending on the medium employed, its concentration and the type of the grain used. The highest rate of germination was found in a Big Oblong type.

The extent of germination increased up to a certain concentration of the medium, after which it decreased. The concentrations of sucrose-gelatin, glucose, laevulose, maltose and starch in which the highest percentage of germination recorded are: 0·75 – 1·0%, 0·75 – 1·0%, 0·5 – 0·75%, 0·1 – 1·0%, 0 25 – 0·5% and 0·5 – 1·0% respectively. Long germ tubes were produced in most cases, the length of the tubes varying from 15 – 600 u. The tube length, however, varied with the concentrations

TABLE V.

Extent of Germination of the Pollen Grains and Length of Pollen tubes of the different types in 24 hours in different media.

| Type: | Big Oblong. | | | | | | Big Round. | | | | | | Small Oblong. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Media: | S | SG | G | L | M | St. | S | SG | G | L | M | St. | S | SG | G | L | M | St. |
| Amounts in Gms. per 100 c.c. of the medium. | Percntage of Germination. | | | | | | | | | | | | | | | | | |
| 0.1 | 6% | 20% | 22% | 25% | 20% | 20% | 5% | 25% | 20% | 50% | 25% | 3% | 15% | 15% | 5% | 10% | 25% | 12% |
| 0.25 | 13 | 30 | 75 | — | 60 | 35 | 7 | 35 | 23 | 20 | 32 | 8 | 22 | 20 | 40 | 15 | 28 | 18 |
| 0.5 | 30 | 45 | 92 | — | 20 | 82 | 15 | 45 | 35 | 18 | 40 | 23 | 28 | 22 | 42 | 25 | 28 | 36 |
| 0.75 | 40 | 48 | 72 | — | 15 | 82 | 17 | 48 | 15 | 15 | 40 | 28 | 48 | 50 | 55 | 25 | — | 39 |
| 1.0 | 85 | 85 | 50 | — | 8 | 72 | 12 | 30 | 12 | 3 | 20 | 26 | 42 | 22 | 30 | 50 | — | 29 |
| 2.0 | 35 | 80 | 30 | — | 5 | 50 | 5 | 12 | 2 | 3 | 20 | 20 | 20 | 20 | 30 | 25 | — | 9 |
| 5.0 | 25 | 50 | 20 | — | 5 | 25 | 5 | 1 | 2 | 3 | 18 | 8 | 12 | 20 | 15 | 25 | — | 3 |
| 10.0 | 22 | 25 | 18 | — | 5 | 25 | 5 | — | — | — | 10 | 2 | 5 | 20 | 5 | 20 | — | 3 |
| | Length of Pollen tubes. | | | | | | | | | | | | | | | | | |
| 0.1 | 51u | 35u | 150u | 120u | 60u | 150u** | 20u | 60u** | 20u | 20u | 25u | 15u | 100u | 120u | 20u | 60u | 100u | 90u |
| 0.25 | 60 | 42 | 400 | — | 75 | 172 | 25 | 60 | 300 | 60 | 200 | 23 | 150 | 300 | 20 | 120 | 60 | 120** |
| 0.5 | 210 | 100 | 600 | — | 90 | 600 | 25 | 90 | 600 | 60 | 350 | 250 | 200 | 500 | 200 | 400** | 60 | 500** |
| 0.75 | 210 | 180** | 120 | — | *120 | 500** | 36 | 90 | 100 | 120 | 500 | 390** | 500** | 355 | 200 | 500** | — | 520** |
| 1.0 | 210 | 500** | 120 | — | *25 | 500 | 36** | 60 | 100 | 15 | 120 | 402 | 450** | 350 | 100 | 500** | — | 530 |
| 2.0 | 60 | 450 | 50 | — | *25 | 40 | 32 | 30 | 15 | 15* | 120 | 120* | 200* | 36* | 100 | 60* | — | 30* |
| 5.0 | 50* | 200 | 30 | — | *15 | 35 | 15* | 30* | 15 | 15* | 50* | 60* | 50* | 30* | 100 | 60* | — | 30* |
| 10.0 | 40* | 45* | 20 | — | *15 | *35 | 15* | — | — | — | 40* | 15* | 50* | 30* | 60* | 60* | — | 15* |

* Grains germinating into big vesicles.

** Tip of germ tubes enlarging into vesicles during or after the first 24 hours of germination.

S — Sucrose; SG — Sucrose 1% gelatin; G — Glucose; L — Laevulose; M — Maltose; St — Starch.

of the media. Pollen grains in very high and low concentrations of solutions directly germinated into big vesicles. The percentages of germination in crushed stigma extracts showed no appreciable variation, but the pollen tubes did not exceed 320 u in length (Table VI).

TABLE VI.

Extent of Germination of the pollen grains and rate of elongation of the pollen tubes in crushed stigma extracts.

| Type. | Percentage of Germination. | Length of pollen tubes. |
|---|---|---|
| Big Oblong. | 60% | 320 u |
| Big Round. | 48% | 250 u |
| Small Oblong. | 46% | 280 u |

The growth in length of the tubes was directly related to the concentration of the medium up to a certain limit, after which it decreased. Long germ tubes and higher extent of germination were invariably found in the same concentrations of the media. The activity of the germ tubes extended for a maximum period of 72 hours, beyond which they gradually became inactive and died. In some cases, where long tubes were produced, growth of the tubes during or after the first 24 hours of germination was associated with the formation of vesicles at the tips arresting further activity. As a rule, growth of the tubes was highest within the first 24 hours; further growth was irregular.

The effect of maturity on the rate of germination of the pollen grains of the different types was also studied. Mature pollen grains were collected in watch glasses and slides from freshly opened flowers and stored for further experiments in the laboratory. Hanging drop cultures were made from the pollen grains after every one hour and the percentage of germination and growth in length of the tubes was measured after 24 hours; results are given in Table VII.

It will be seen that

(i) the longevity of the pollen grains was from 8-9 hours after maturity.

(ii) maximum germination associated with the formation of long tubes was observed in the grains germinating during the first 2-4 hours after maturity.

(iii) the extent of germination of the fresh grains was from 25·5-48·8% of the total germination and only short tubes were produced.

TABLE VII.

LONGEVITY OF THE POLLEN.

Percentages of germination and length of Pollen tubes after hours.

| Type. | Control* | 1 hr. | 2 hrs. | 3 hrs. | 4. hrs. | 5 hrs. | 6 hrs. | 7 hrs. | 8 hrs. | 9 hrs. |
|---|---|---|---|---|---|---|---|---|---|---|
| Big Oblong.% | 20% | 50% | 70% | 72% | 60% | 28% | 14% | 6% | 3% | — |
| Length. | 20u | 20u | 220u | 550u | 250u | 20u | 20u | 20u | 10u | — |
| Big Round. % | 10% | 22% | 30% | 40% | 40% | 32% | 10% | 8% | — | — |
| Length. | 25u | 100u | 210u | 420u | 420u | 200u | 100u | 82u | — | — |
| Small Oblong.% | 21% | 23% | 29% | 38% | 43% | 42% | 32% | 18% | 6% | — |
| Length. | 60u | 66u | 120u | 220u | 510u | 510u | 266u | 200u | 20u | — |

* Control = Fresh pollen.

The effect of temperature on the rate of germination of the pollen grains was studied by using hanging drop cultures of 1·0% sucrose, 1·0% sucrose-gelatin, 0·5% glucose, 0·1% laevulo, 0·25% maltose and 0·5% starch at 35 ± 1°C for different periods. The slives were incubated for 2-3 days; percentages of germination and the average length of the tubes were measured. The results showed that the grains failed to germinate in all cases irrespective of the duration of treatment. In one case, however, when maltose was used as the medium, 2-3% of the grains produced short tubes after 1 hour treatment; no further germination was evident.

In another set of experiments the slides were exposed to treatment of 20 ± 1°C in an incubator. The observations recorded during the first 24 hours of germination are given in Table VIII.

The results show that temperatures of 20 ± 1°C and 35 ± 1°C do not favour successful germination of the pollen grains. While there was practically no germination at 35 ± 1°C, the number of germinated grains at 20 ± 1°C decreased steadily with increased duration of treatment, the decrease in the percentage of germination being associated with the production of short germ tubes.

TABLE VIII.

Percentage of germination and length of the pollen tubes at 20 ± 1°C.

| Treatment. | Sucrose. | Sucrose Gelatin. | Glucose. | Leavulose. | Maltose. | Starch. |
|---|---|---|---|---|---|---|
| Control % | 61% | 63% | 75% | 22% | 16% | 65% |
| Length. | 421u | 392u | 576u | 223u | 138u | 568u |
| 20 ± 1°C. | | | | | | |
| 1 hr. daily. % | 50% | 53% | 63% | 17% | 15% | 63% |
| Length. | 215u | 50u | 220u | 40u | 100u | 428u |
| 2 hrs daily % | 40% | 40% | 60% | 10% | 10% | 42% |
| Length. | 175u | 15u* | 200u | 19u* | 60u | 200u |
| 4 hrs. daily % | 33% | 38% | 13% | 15% | — | 10% |
| Length. | 60u | 15u* | 150u | 15u* | — | 60u |
| 8 hrs. daily % | 30% | 33% | 10% | — | — | — |
| Length. | 60u* | 15u* | 20u | — | — | — |

* Pollen grains germinating into big vesicles.

A comparative study of the germination of the pollen grains in relation to the viability of the stigmas of the fresh and fallen flowers with increasing maturity was also made. This may be important in view of the fact that chances for a quick pollination of the flowers as soon as they open are found to be rare. An examination of the scrappings of the stigmas, subsequent to opening of the flowers showed that only a small percentage of the flowers have been pollinated. Under natural conditions, it is also not uncommon to see open flowers remaining still unpollinated for 4-5 days after opening and ultimately abscissing. Hence, an attempt was made to determine the percentage of germination of the pollen grains on the stigmatic surfaces of various stages of development in fresh flowers as well as in the fallen flowers. Crushed stigma extracts of the different groups of fresh and fallen flowers collected at random from two different plantations were made and the pollen grains cultured in them by the hanging drop technique. The extent of germination recorded after the first 24 hours is given in Table IX.

TABLE IX.

Viability of the stigmatic surfaces of the flowers of different degrees of maturity.

Percentage of germination of the pollen grains stigma extracts of

| | Fresh flowers. | | | | Fallen flowers. | | | |
|---|---|---|---|---|---|---|---|---|
| | Closed | Slightly open. | Fully open. | Old. | Closed | Slightly open. | Fully open. | Old. |
| 1. | — | 38% | 30% | 10% | — | 32% | 17% | 10% |
| 2. | 10% | 53% | 52% | 30% | 6% | 42% | 40% | 18% |

It will be seen that :

(i) stigmatic surfaces lose their viability under natural conditions with increasing maturity of the flower.

(ii) in closed flowers stigmas are the least viable.

(iii) stigmas exhibit their maximum viability when the flowers slightly open their perianth lobes and expose the stigmas.

(iv) with the abscission of the flowers, stigmas lose their apparent viability considerably. However, they retain their receptivity to some extent even after they have abscissed from the infloresence.

## DISCUSSION AND CONCLUSIONS.

Some of the main conclusions reached above are as follows :—

It has been generally observed that in arecanut palms there has been a considerable extent of sterility resulting in low yield of fruits. An estimate is here given of the extent of sterility of the various types of *Areca catechu* grown in Assam, as well as of the factors which influence pollination. It has become apparent that sterility is possibly due to : (i) non-uniformity in the time of maturity of the male and female parents with considerable lag in between the phases (ii) differences in the extent of sterility in the male flowers (iii) failure of pollen grains to germinate (iv) slow growth of the pollen tubes and their subsequent death in the stylar canal resulting in failure of fertilization and (v) short longevity of the pollen grains and the stigma.

It may be noted that the first described above is a natural adaptation to prevent self-pollination because of the time lag between opening of the male flowers and the female ones. Sands (1926), however, indicates the possibility of pollination from the male flowers of the spadix successively opening in the same palm.

The extent of sterility in the male flowers of the different types is considerably high. Sterility during formation of the microspores originates as a result of the failure of one division or the formation of 'restitution nucleus' after the first division or an irregular wall formation giving rise to one binucleate and two uninucleate spores (Mheshwari, 1950): sterile grains may also be formed by the irregularity in chromosome distribution during meiosis leading to polyspory (Sharp, 1934). Other cytological data, are however, at present, lacking. High sterility is generally characteristic of hybrids and the question whether the different types of arecanuts are really morphologically different or merely unstable hybrids requires further investigation.

Although sterility in the male flowers influences fruit-set, the lodging of the pollen grains on the stigma under natural conditions and its subsequent germination leading to fertilization of the ovule are also important factors in the formation of fruits. It is observed that not more than 75% of the flowers actully receive pollen on their stigmatic surfaces. Naik and Rao (1943) and Mukherjee (1951) working on the blossom biology of mangoes have made similar observations. The main problem, however, is not in regard to the lodging of the pollen grains on the stigmas and their capacity to germinate, but the active growth of the pollen tubes inside the stylar canal leading to fertilization of the ovule. The failure of the pollen tubes to fertilize the ovules may be due to: (i) maximum length of the pollen tubes being inadequate to reach the ovule (ii) medium of the stylar canal favouring inhibition of growth (iii) bursting of the pollen tubes in the stylar canal of formation of vesicles at the tip of the tubes. Evidence is already given of the frequent occurrence of such vesicles at the tip of the tubes in cultures. The ephemeral nature of the pollen grains and the degree of receptivity of the stigmas are also factors that determine successful pollination and fertilization. In the case of arecanuts, pollen grains lose their viability whithin 8 to 9 hours after maturity; stigmas in mature flowers also exhibit rapid loss of receptivity. It has been further found that certain nutrient solutions favour production of long tubes and successful germination of the pollen grains. This may serve as a basis for further studies on specific stimuli or auxins that may be responsible for quicker initiation of germination and more active growth of the pollen tube than hitherto obtained. There is, however, evidence that even the stylar extracts do not increase sufficiently the extent of germination of the pollen grains.

It is evident, therefore, that failure of pollination and fertilization primarily accounts for a considerable proportion of the fallen flowers in arecanut palms. Approximately 15% of the flowers wither and abscise in the young stages before there could be any chances for pollination. The factors which influence the abscission of the young flowers are still imperfectly understood.

## SUMMARY.

1. The fruit-set and sterility of the different types of arecanuts in Assam are studied; 48 - 65% of the female flowers only set fruits and mature.

2. Pollen grains of the different types are morphologically similar, but the anthers exhibit varying degrees of sterility, grains being sterile, imperfect or fertile.

3. The fall of female flowers during premature stages is due to failure in pollination and fertilization.

4. The extent of germination of the pollen grains and the rate of growth of the pollen tubes are studied under different conditions.

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