Annual Report of the Central and Regional Arecanut Research Stations

1967

Central Arecanut Research Station, Vittal,
Mysore State, India
1969

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1st January, 1967 to 31st December, 1967

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Mysore State, India

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CONTENTS

I. DIRECTOR'S INTRODUCTION

A BRIEF HISTORICAL INTRODUCTION

The Central Arecanut Research Station, Vittal was started by the erstwhile Indian Central Arecanut Committee in April 1956. It is located in Vittal Village, Bantwal Taluk of South Kanara District of Mysore State, 45.0 km from Mangalore Railway Station on the Mangalore-Vittal-Puttur highway. It lies on 12.25° north latitude and 75.42° east longitude. The altitude of the Station is about 200 m above mean sea level. The rivulet Vokkethur is the main source of irrigation. The soil at the Station is typically lateritic and is admixed with sand, alluvium and gravel. It is acidic with a pH value around 5.25. The total area of the Station is 56.82 ha.

Besides the Central Station, there are five Regional Research Stations located at Kahikuchi, Mohitnagar, Hirehalli, Peechi and Palode.

The Station at Kahikuchi is located near Gauhati air port at a distance of 22 km from Gauhati Railway Station in Assam. The altitude of the Station is 48 m above mean sea level, the latitude and longitude being 20 18° north and 91.78° east respectively. The soil is new alluvium with lower strata of lateritic and has a pH of 4.4 to 4.8. The total area of the Station is 12.14 ha.

The Station at Mohitnagar is located near the Mohitnagar Farm of West Bengal Government at a distance of 9.6 km north-west of Jalpaiguri Railway Station on the Jalpaiguri-Siliguri road. It lies on 26.52° north latitude and 88.72° east longitude. The soil is acidic and has a pH range of 4.5 to 6.0. The total area of the Station is 10.11 ha.

The Station at Hirehalli is located near Hirehalli Railway Station, Tumkur District (Mysore State), on the Bangalore-Poona National Highway, 58 km from Bangalore. It lies on 13.08° north latitude and 77.12° east longitude. It is about 854 m above mean sea level. The soil of the Station is clay to clay loam with a mean pH of 6.2. The total area of the Station is 16.24 ha.

The Regional Station, Peechi is at Kannara of Trichur District in Kerala State and is situated 19.3 km east of Trichur Railway Station. It is located at 10.50° north latitude and 76.17° east longitude. The altitude of the Station ranges from 49 to 55 m above mean sea level. The

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upper layers of the soil are mainly of the alluvial type with good admixture of sand and silt and the lower layers are lateritic. The pH of the soil ranges from 5.6 to 6.8. The total extent of the Station is 14.16 ha.

The Regional Station, Palode is located in Palode Village of Nedumangad Taluk of Trivandrum District of Kerala State and is 36 km away from Trivandrum City. It lies at 77.03° east longitude and 8.07° north latitude. The altitude of the Station ranges from 210 to 240 m above mean sea level. The soil is mainly lateritic with pH ranging from 4.2 to 5.0. The total area of the Station is 11.77 ha.

The Central and Regional Stations were under the control of the Indian Central Arecanut Committee and on its abolition they were taken over by the Indian Council of Agricultural Research in April, 1966.

OBJECTIVES

The Central Station is charged with the functions of (i) conducting fundamental and applied research on Botany, Agronomy, Chemistry, Physiology and Pests and Diseases aspects of the arecanut crop, (ii) guiding and coordinating the research work carried out at the different Regional Arecanut Research Stations in the country, (iii) solving the regional problems confronting the arecanut crop and (iv) serving as a centre of information on all matters relating to the arecanut crop. The Regional Stations at Kahikuchi, Mohitnagar, Hirehalli and Peechi are to deal with the various agronomic and pests and diseases problems relating to the arecanut crop peculiar to the respective regions as well as to serve as testing centres of the research findings of Central Station for adoption in the region. The Stations are also to supply quality planting material to the growers. The Research Station at Palode was started mainly to tackle the yellow leaf disease of arecanut palm which is a serious problem of the tract and also to handle some of the important agronomic problems of the region.

ORGANISATIONAL STRUCTURE AND CHANGES

Research at the Central Station is being carried out in seven sections viz., Botany, Agronomy, Statistics, Chemistry, Physiology, Pathology and Entomology. The work of each section is under the immediate charge of the concerned Section Head, who is assisted by Research Assistants. The Regional Stations are under the immediate charge of the respective Research Officers who are assisted by Research Assistants. The administration of the Central and Regional Stations is being carried out with the help of a separate Administrative section. The overall control of the Central and Regional Stations rests with the Arecanut Specialist who is the head of the Central Station.

The Central Station has a library which is accessible to the research workers of Regional Stations also. The Regional Stations also have each a small library for immediate reference.

During the year under report the scheme on comprehensive package plan trials on yellow leaf disease of arecanut (under the aegis of Indian Council of Agricultural Research) was closed and the remaining work under the project brought under the normal activities of the Station.

DISTINGUISHED VISITORS

As usual a large number of visitors consisting of officials of State Department of Agriculture, Scientists from different organisations, graduate and post-graduate students of different Agricultural Colleges and Universities and individual farmers and farmers' organisations visited the Central and Regional Stations. Special mention has to be made of the visit of six students of State College of Missouri, U. S. A. to Regional Arecanut Research Station, Kahikuchi and that of Estimates Committee of Government of Kerala to Regional Arecanut Research Station, Peechi.

Among other important visitors to Central Arecanut Research Station were Drs. K. Thirumalachar, C. V. Dhulappanavar, K. Krishnamurthy and Shri K. C. Devaraju and Shri B. G. Rajasekharan of University of Agricultural Sciences, Bangalore; Mr. and Mrs. I. F. Karukhov of the Embassy of U. S S. R ; Shri T. Vijayan Nair from FACT, Alwaye; Rajkumar P. V. Gajapati Raju of Vizianagaram; Shri P. N. Baljekar of Vishwaneedham Farms, Bangalore; Shri A. Krishnan of INSDOC, Bangalore; Mr. Esmail Iaknejaddi from Iran; Shri P S. Hariharan, Additional Secretary, Indian Council of Agricultural Research, New Delhi and Profs. K. N. Narayanan and M. N. Viswanathaiah of the Mysore University. Among the important visitors to Regional Stations were Shri P. Goswami, Minister for Agriculture, Assam; Shri V. Sharma, President, Rotary Club, Gauhati; Shri G. Baruah, I. A. S., Principal, Administrative Training College, Assam; Shri T. T. Paulose, Dy. Director, Arecanut and Spices Development; Shri K. P. A. Menon, Secretary, I. C. A. R., New Delhi; Shri K. Sundaram Pillai and Shri C G. Selvaraj, Plant Protection Officers, Government of India, Shri T. K. Krishnan. Chairman, Estimates Committee, Government of Kerala and Shri S. Chakrabarthy, Joint Director of Agriculture, Jalpaiguri.

IMPORTANT EVENTS OF THE YEAR

A team constituted by the Mysore University visited the Central Station to assess the possibility of recognising the same as a centre for post-graduate work. The first technical bulletin of the Station - Bibliography on arecanut - was published during the year. The first conference of arecanut research workers was held at Hirehalli during July, 1967. A total area

of 14.66 ha. of land for which acquisition proceedings were underway was taken possession. Construction of an all-weather motorable bridge connecting the two portions of the farm was completed and the bridge opened for traffic. A vented dam constructed along with the bridge was also made available by the State Public Works Department for the use of the Research Station.

RESEARCH COLLABORATION AT NATIONAL LEVEL

Facilities available at the Central Food Technological Research Institute, Mysore were availed of for chemical analysis of cured nuts of some of the exotic varieties for evaluating their relative merits. For enriching the germplasm bank at the Central Station a total of five introductions were obtained from foreign countries through the Plant Introduction Division of Indian Agricultural Research Institute. Field facilities were provided for the Central Tuber Crops Research Institute for laying out extensive field experiments with tapioca varieties. The Engineering Research Institute, Peechi of the Kerala State Goverment which approached the Research Station for certain field facilities at the Regional Arecanut Research Station, Peechi for taking up an irrigation experiment on arecanut was provided with necessary help.

RESEARCH COLLABORATION AT INTERNATIONAL LEVEL

Progress was made in the rearing of a predator for the biological control of mites in collaboration with the Commonwealth Institute of Biological Control, Bangalore. A number of specimens were got identified by the Commonwealth Entomological Institute, London.

FELLOWSHIP AND STUDENTSHIP

Three of the staff members joined for post-graduate course in Agronomy, Botany and soil Chemistry. One of them was awarded an I.C.A.R. fellowship for the study.

RESEARCH ASSOCIATIONS

A meeting of the reconstituted Research Council was held during the year at the Regional Arecanut Research Station, Hirehalli. Every project of the technical programme was discussed in detail and some of them reoriented. Under the aegis of the Study Circle the first conference of arecanut research workers in which all the research staff of Central as well as Regional Stations, delegates from the University of Agricultural Sciences, Bangalore and the Department of Horticulture, Mysore participated, was organised. Large number of papers were presented and discussed.

ADVISORY SERVICES RECEIVED AND PROVIDED

The Central Station gave suggestions in drawing up the technical programme of Mysore State Regional Arecanut Research Station, Thirthahalli. The Arecanut Specialist was a member of the Development Council for Arecanut and Spices, Calicut and Arecanut Sub-Committee of the Indian Standards Institution, New Delhi. He attended the meetings and gave suitable advice on various technical matters. The Agronomist was a member of the Sub-Committee to review the report on Pilot Sample Survey for correct estimation of area and production of arecanut.

The Station consulted Dr. B. R. Murthy and Dr. V. Santhanam of Indian Agricultural Research Institute, Dr. C. O. Gardner of University of Nebraska, U. S. A., Dr. E. B. Snyder of Institute of Forest Genetics, Mississippi and Dr. Jowett of Iowa State University for finalising a breeding programme on arecanut. The Institute of Agricultural Research Statistics was consulted about the designs of certain field experiments.

In addition to normal activities of research, numerous enquiries that were being received by the Central and Regional Stations seeking advice on various problems connected with the crop such as cultivation practices, spacing and layouts to be adopted, fertilizers and manures to be applied, examination of plant parts affected by various diseases and pests and proper methods of their control, methods of preparation of nuts for the market etc., were suitably answered. Requests for spot inspection, selection of site and layout of gardens received were also attended to wherever feasible. The Central and Regional Stations were also centres of study tour.

EXTENSION

To the numerous cultivators who visited the Station proper advice was given regarding the various aspects of arecanut cultivation. A total of 11,147 seednuts and 44,917 seedlings were distributed during the year.

FINANCE

The sanctioned budget of Research Station for the financial year 1967-68 was Rs. 8.42 lakhs including a provision of Rs. 1 lakh for two schemes on arecanut. The expenditure on major heads was of the following order:

1.	Pay and allowances of staff	Rs. 3,22,213.00
2.	Working expenses	Rs. 3,20,042.00
3.	Schemes on arecanut	Rs. 77,305.00
	Total:	Rs. 7,19,560.00

The revenue receipts of the station touched a figure of Rs. 1,18,500 against Rs. 97,500 realised during the previous year.

II. PROGRESS OF RESEARCH

BOTANY

(In-charge : K. V. Ahamed Bavappa)

SUMMARY OF SALIENT FINDINGS

Studies on the floral initiation in arecanut have shown that there is one inflorescence initiated in every leaf axil. Differentiation of the inflorescence primordia commences when it is located in the axil of the fourth unopened leaf. Initiation of the male and female flowers takes place when the inflorescence is in the axil of the spindle leaf and the first opened leaf respectively. Inflorescence located in the sixth leaf axil in February to May appears to get aborted to a greater extent. Abortion takes place at a stage when inflorescence starts developing rapidly. Age of palms, management conditions and season are found to influence abortion of inflorescence. Nuts of five exotic introductions and three indigenous types were analysed and the quality compared with that of Sreevardhan type, keeping it as the standard. Four distinct cultivars were isolated in the arecanut growing tracts of North Gauhati of Kamrup District. Comparison of growth characters of progenies of eight mother palms grown at Hirehalli revealed significant difference between families for mean girth. A similar comparison made at Peechi for productive characters showed wide variation between families in respect of mean number of female flowers. Floral biology studies at Kahikuchi have shown that male phase ranges from 5-29 days in more than 90 per cent of the inflorescences and female phase ranges from 3-8 days in more than 80 per cent of the inflorescences. Overlapping of male and female phases within the same bunch occurs in 8 percent of the inflorescences. Growth measurements of progenies obtained by self and open pollination showed that height and girth are less in the case of self-pollinated ones. A. crossing programme making use of the principle of polycross was included in the Mass pedigree system of selection that is in progress. The leaf-epidermal pattern of exotic types was studied and the results revealed that there is significant variation between types in respect of epidermal characters. Assisted pollination trials revealed that the fruit-set can be increased by about 10 per cent if pollination is assisted which could be further enhanced by about six per cent if Gibberellic acid is added. An increased set of 16.27 per cent was

obtained at Kahikuchi by spraying Bordeaux mixture 1% + Endrin (125 ml in 100 litres of Bordeaux mixture) in two rounds.

(a) RESEARCHES COMPLETED

B. 8. Floral initiation

Fourteen crowns of 10-year old palms grown under average soil fertility and management conditions were dissected in the month of June. Four crowns from another set of trees of the same age grown under completely neglected conditions (no irrigation, no manure) were also dissected. All the opened leaves, the spindle and unopened leaves up to 7th leaf were removed and the primordia with the remaining leaves fixed in formalin acetic alcohol (FAA). Microtome sections were cut at 12 microns and the sections stained with safranin. For identifying the different leaves in the crown for the matter of description, spindle leaf was considered as 0 and the unopened leaves inside the crown as 1, 2, 3, 4, ... upwards from the spindle (−) and those which are outside as 1, 2, 3, 4, ... opened leaves (+) downwards. Sections of the primordia from five palms were examined. Leaf fall, inflorescence and flower production and fruit-set in respect of 300 palms grown at the Central Arecanut Research Station gathered from their commencement of bearing in the fifth year of planting were examined. The results are summarised below:

a) Floral initiation and development

Detailed dissection studies showed that the crowns had 8 to 9 opened leaves, one spindle leaf and 10 to 13 leaves and leaf primordia in varying stages of development. It was also observed that there was inflorescence initiation in every leaf axil up to the growing point. The inflorescence primordia are initiated alternating with leaf primordia. The size of inflorescence subtended by each leaf was also found to vary considerably (Table 1).

It will be seen from Table 1 that the rate of growth of the inflorescence is slow till it reaches the axil of the sixth opened leaf. Thereafter, there is almost a regular doubling in length.

TABLE 1

Mean length of inflorescence subtended by different leaves

Type of leaf	Leaf No.	Length of inflorescence (cm)
Opened leaves (+)	9	29.80
	8	17.70
	7	8.20
	6	4.30
	5	2.90
	4	2.20
	3	1.80
	2	1.40
	1	1.20
Spindle	0	0.67
Unopened leaves (–)	1	0.45
	2	0.30
	3	0.25
	4	0.20

The inflorescence primordium subtended by the 4th unopened leaf was found to show the initial differentiation into primary rachis. Continuing the observation, in the case of subsequent inflorescences it was observed that the one in the 2nd unopened leaf had differentiated into secondary rachis. The spathe covering the spadix was also found to be differentiated at this stage. The inflorescence located in the 1st unopened leaf had the tertiary rachis and the filaments. The initiation of male flowers was found to commence from the inflorescence subtended by the spindle.

The growth of filaments and initiation of the male flowers were found to continue in the case of the inflorescence located in the axil of 1st opened leaf. Initiation of female flower was also found to commence at this stage. Initiation of all the male & female flowers was found to be complete in the inflorescence located the 6th leaf axil. The inflorescence at this stage has a mean length of 4.3 cm. It was also observed that all the 16 secondary rachis that are normally observed in a fully developed inflorescence are present adpressed side by side indicating that the initial primordium which is located horizontally to the stem has a simultaneous differentiation into different secondary parts.

b) Inflorescence abortion

In order to study the relationship, if any, existing between inflorescence abortion, leaf emergence and leaf fall, data on the interval between leaves shed and leaves produced in respect of a number of plants were gathered. The mean data in respect of nine leaved plants are given in Table 2.

TABLE 2

Mean interval (days) between successive leaf emergence and leaf fall

Interval	Leaf emergence	Leaf fall
1st	44.7	48.7
2nd	47.3	44.4
3rd	42.9	41.0
4th	39.6	37.0
5th	39.1	33.5
6th	44.1	42.0
7th	48.0	54.3
8th	41.0	46.8
Mean	43.3	43.4

It will be seen from the above that the mean interval between the emergence of two leaves and mean interval between leaf fall are more or less the same.

Month-wise data on percentage of inflorescence produced to leaf fall gathered for seven years are given in Table 3. From the table it will be seen that there is considerable variation in the inflorescence production in different months of the year as well as between different years. More than 50 per cent of the inflorescences are aborted in the case of leaves shed in the months of July, August and September.

TABLE 3

Percentage of inflorescence produced to leaf fall

Month	1961–62	1962–63	1963–64	1964–65	1965–66	1966–67	1967–68	Mean percentage for each month
July	11.20	45.35	65.90	33.93	34.90	32.50	70.70	42.07
August	21.80	52.45	50.10	29.00	31.90	39.80	39.70	37.82
September	35.80	71.96	55.70	36.60	45.00	58.00	29.30	47.50
October	54.00	74.80	64.00	46.60	49.70	89.50	33.70	58.90
November	61.97	84.64	84.90	59.00	76.00	88.20	38.00	68.96
December	76.19	84.76	82.40	78.07	99.40	93.20	67.00	83.00
January	89.03	90·64	87.90	90.00	96.50	98.10	90.70	91.84
February	87.45	94.06	93.70	92.30	97.40	99.00	94.30	94.03
March	58.13	90.00	88.30	94.10	94.30	100.00	96.70	88.79
April	69.68	83.81	84.80	91.30	80.00	95.70	95.30	85.80
May	37.47	67.60	66.00	84.40	63.80	97.20	94.70	73.02
June	35.26	79.20	76.80	65.80	47.40	81.30	48.00	61.97
Mean percentage per year	53.16	76.61	74.22	66.76	68.02	81.04	66.51	

The monthly variations in respect of female flower production and flower set were also studied. The data gathered are given in Table 4.

TABLE 4

Monthly variation in female flower production and flower set

Month	Mean female flower per inflorescence	Mean percentage of female flowers set
July	86.6	9.6
August	56.3	6.8
September	119.3	8.9
October	154.3	19.4
November	174.6	20.5
December	190.9	28.4
January	189.0	29.8
February	217.4	31.3
March	238.3	76.4
April	215.5	21.0
May	165.4	18.2
June	123.0	10.7

It will be observed from Table 4 that the mean number of female flowers produced per inflorescence and flower set are low during the months of June to September.

Inflorescence abortion observed under different management conditions of the plantation is given in Table 5.

TABLE 5

Mean percentage of inflorescence abortion under different management conditions

Management condition	Leaf number (from spindle)					
	9	8	7	6	5	4
Average	60	20	20	—	—	—
Neglected	80	100	60	20	—	—

The results show that for corresponding leaf axils the percentage of inflorescence abortion is considerably high under neglected conditions.

The lengths of the aborted inflorescences located in the different leaf axils in relation to others in different stages of development are presented in Fig. 1.

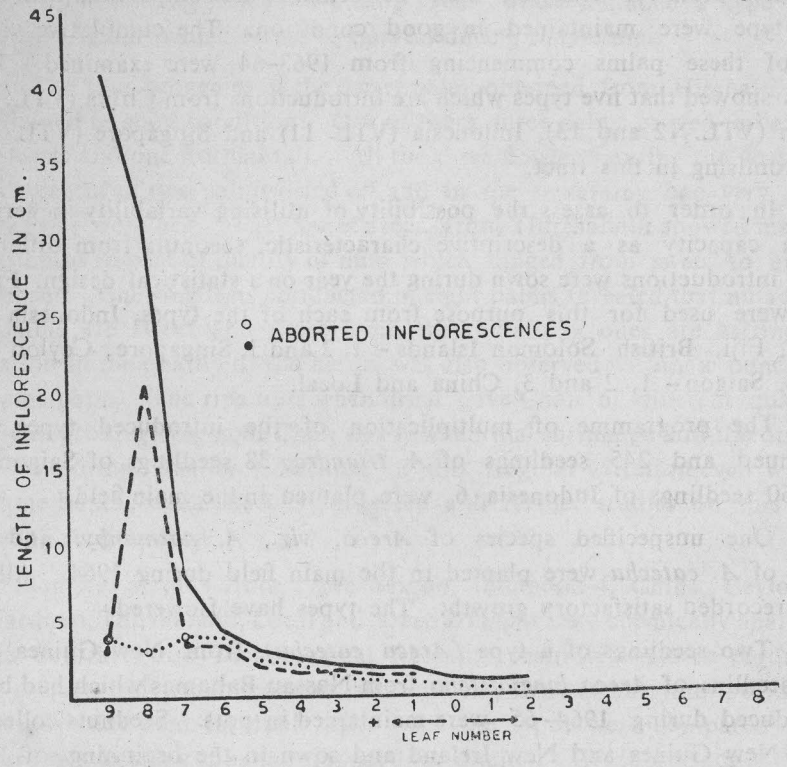


FIG. 1 The development of inflorescence in three arecanut palms (leaf 0 is spindle leaf)

It will be seen from the figure that the length of the inflorescence aborted is more or less the same.

(b) RESEARCHES IN HAND

B. 1. Introduction and maintenance of indigenous and exotic species and types of areca for selection and hybridisation

a) Exotic types collection

The four palms introduced from Indonesia, Nicobar and Andaman and planted in 1957 continued to show decline in yield. Since the plants had initially shown prolific bearing their progeny and certain crosses are being studied separately. The decline of the palms seems to be due to unfavourable soil conditions under which they were planted.

Seventeen species and types introduced from eight countries viz., Saigon, Indonesia, Fiji, China, Ceylon, Mauritius, Singapore and British Solomon Islands and planted in 1961 in a randomised block design with single tree plots for studying their performance in comparison with the local type were maintained in good condition. The cumulative yield data of these palms commencing from 1963-64 were examined. The results showed that five types which are introductions from China (VTL. 3), Saigon (VTL. 12 and 13), Indonesia (VTL. 11) and Singapore (VTL. 17) are promising in this tract.

In order to assess the possibility of utilising variability in germination capacity as a descriptive characteristic, seednuts from different exotic introductions were sown during the year on a statistical design. Fifty nuts were used for this purpose from each of the types, Indonesia – 4 and 6, Fiji, British Solomon Islands – 1, 2 and 3, Singapore, Ceylon - 1 and 2, Saigon – 1, 2 and 3, China and Local.

The programme of multiplication of the introduced types was continued and 245 seedlings of *A. triandra*, 38 seedlings of Saigon–2 and 60 seedlings of Indonesia-6 were planted in the main field.

One unspecified species of *Areca, viz., A. normanbyi* and ten types of *A. catechu* were planted in the main field during 1964. All of them recorded satisfactory growth. The types have flowered.

Two seedlings of a type *(Areca catechu)* from New Guinea and nine seedlins of *Areca langloisiana* from Nassau Bahamas which had been introduced during 1964-65 were maintained in pots. Seednuts collected from New Guinea and New Ireland and sown in the beginning of 1967 germinated satisfactorily. The following are the introductions of the year.

1. Bougain ville– 1
2. Bougain ville– 2
3. Bougain ville– 3
4. Polepole (Port moresby)
5. *Areca macrocalyx*
6. *Areca novohibernica*

The germination was satisfactory. Seednuts of *Areca rostrata* were also received from New Guinea and sown at the Station. But all the nuts failed to germinate.

The Regional testing and multiplication of the introductions were in progress and seednuts were sent to all the Regional Stations. A total of 150 nuts to Hirehalli, 60 to Peechi, 95 to Palode, 105 to Kahikuchi and 90 to Mohitnagar were sent during the period.

b) Indigenous types collection

Thirteen types collected from different tracts of the country were planted at the Central Station in the year 1964. Four more types were added to the existing collection during 1966. These included a type from Kamrup (Assam) which comes to harvest during May-June.

The four progenies of the dwarf palm obtained from Hirehalli were maintained in good condition. Out of them, three palms proved to be typical dwarfs and one normal tall. All the three flowered during the year, but inflorescences of two palms dried off and in the remaining one very good nut set was obtained. The 'Sweet areca' from Thirthahalli showed marked variation in respect of quality of nuts which ranged from sweet to highly astringent. Chewing tests conducted in eight palms revealed that nuts from five palms are sweet and those from the remaining ones are astringent. Variation in the quality of the kernel was also observed within a bunch of the same palm. The ripe nuts when dried gave Chali of different quality, the sweet group giving poor Chali due to abnormal shrinkage and the others, chali of normal quality. Because of this irregular variation even within the same bunch, xenia effect is suspected and further studies on this line are being programmed.

Samples of nuts from types Saigon, Indonesia-4, China, Ceylon-1, Sreevardhan, Thirthahalli, Local and *Areca triandra* were chemically analysed at the Central Food Technological Research Institute, Mysore for total water extract, polyphenol content, alkaloid, fat, FAA on fat, total polysaccharides, ash and acid insoluble ash. All the types were compared with Sreevardhan, keeping it as the standard for quality. Wide variability was not observed in any of the types in respect of the components analysed.

The performance of different indigenous and exotic types was being tested at the Regional Stations also. At Palode 13 types (Andaman, Indonesia-1 and 2, Nicobar, Thirur, Kumaranellor, Perigamukku, Telur, Wangi, Thirthahalli, Hirehalli-1 and 2 and Local) were under trial. The results of the studies showed that in respect of total height and number of nodes Andaman, Indonesia-1 and Nicobar were significantly less superior than the rest.

A total of 144 seedlings of six distinct types viz., Vittal, Tumkur, Peechi, K & J Hills, Cachar and Kamrup were planted at Kahikuchi in 1961. The growth measurements and productive characters were statistically analysed and the results showed that the local type (Kamrup) is significantly superior to all others in respect of production of inflorescence as well as percentage of inflorescence to leaf fall.

B. 2. Survey of arecanut gardens to assess the genetic variation and selection of common cultivars

This survey was in progress at the Regional Stations of Peechi, Hirehalli and Kahikuchi with a view to determining the extent of variability existing in different arecanut growing tracts and to isolate suitable cultivars. The entire area was divided into three major tracts viz., (1) coastal sandy tract, (2) upland hilly tract and (3) plain midland tract. Selection of villages and gardens and sample survey of nuts in 22 gardens of 11 villages in the plain midland tract and 12 gardens in 6 villages of the coastal sandy tract were taken up. The survey in the remaining tracts is in progress. The same study was conducted at Kahikuchi also. Four distinct cultivars were selected from one of the tracts. At Hirehalli also the survey was continued and the data are under scrutiny.

B. 3. Studies on the performance of progenies of known mother palms and the mother palm progeny relationship

Based on progeny studies 'prepotent' mother palms had been isolated. In order to study the repeatability of prepotency, seedlings of nine mother palms were planted during 1966 on a compact family block design with five replications. A total of 180 progenies are under study and the growth data of seedlings collected were analysed. The results showed that the different families do not differ significantly for seedling vigour.

At Hirehalli, progenies of eight mother palms collected from the locality were under comparison on an 8 x 4 randomised block design for isolating 'prepotent' mother palms. The growth measurements were analysed and the results showed that the mean girth of progenies of two mother palms was significantly more than the rest. The data recorded on the productive characters were analysed and the mean percentage of inflorescence to leaf fall showed a very wide variability between the different families.

A similar study is in progress at Peechi with the progenies of four mother palms. Wide variation was observed between families in respect of mean number of female flowers.

B. 4. Production of inbred lines of distinct types

Floral biology studies for finding out the extent of selfing and crossing taking place in arecanut had been completed at the Central Station during the previous year. The study was being continued at the Regional Stations to find out the variability in respect of the above characters existing in those regions. The data collected at Kahi-

kuchi showed that male phase ranged from 5 to 29 days and female phase 3 to 8 days. It was also found that overlapping of the male and female phases between different bunches of the same tree occurs in 24 per cent of the inflorescences and within the same bunch in 8 per cent of the inflorescences. During the previous year also an almost identical trend in duration of male and female phases and their overlappings had been observed.

For evolving suitable inbred lines of arecanut the programme of selfing was in progress. A total of 612 nuts of exotic introductions from China, Saigon, Singapore, Indonesia and Ceylon obtained by intercrossing palms of the same type which were sown last year have been transplanted to the secondary nursery during the year. In addition to this, *Areca triandra*, Sreevardhan, Thirthahalli, China and Local (prepotent palm) have been selfed and sown in the primary nursery. Sixty four seedlings of mother palms K. M. J. 13, and N. G. B. 293 selfed and open pollinated in both the cases were planted in the main field in a 2 × 16 randomised block design with two palms per plot. Growth measurements taken at the time of planting showed that the measurements relating to height and girth were less in the case of progeny obtained by self pollination.

B. 5. Hybridisation between exotic and indigenous types and species

In order to make the maximum use of the available genetic materials, a crossing programme using the different types and species available at the Central Station was in progress. Crosses involving VTL. 3 (for semi-tallness and number of inflorescences) Sreevardhan (for quality of nuts), *Areca triandra* (for large number of female flowers and high set) were made. Hybrid nuts obtained were sown in the nursery. A total of 71 hybrid nuts from the interspecific crosses involving *A. catechu* and *A. triandra* were also sown. Seventy five nuts obtained from crosses between prepotent palms and the exotic types viz., VTL. 3 (China), Singapore and Saigon-3 were also sown. The sprouts were transplanted to the secondary nursery.

Seedlings from the crosses *A. triandra* X *A. catechu* and the reciprocal crosses were planted in a 4 × 8 randomised block design along with *A. catechu* and *A. triandra* for comparison. The growth measurements taken at the time of planting showed that the hybrids are intermediate to the parents in respect of height and number of leaves and less than both the parents for girth.

B. 6. Efficiency of phenotypic selection of mother palms, seednuts and seedlings.

This study was initiated during 1963-64 with a view to finding out how far selection of seednuts and mother palms influences germination and turn over of quality of seedlings in the primary and secondary nurseries as well as their performance in the main field. The experiment was laid out on a 4×6 randomised block design with the following treatments.

1. Unselected bulk nuts
2. Selected bulk nuts
3. Unselected nuts from mother palms
4. Selected nuts from mother palms

Based on visual observation the seedlings in the secondary nursery were grouped before planting as (1) selected and (2) rejected and all the seedlings transplanted. The annual growth measurements of the first year showed that the treatments did not differ significantly for any of the characters studied. Two more treatments viz., selected nuts from non-prepotent mother palms and selected nuts from prepotent mother palms were included during the year making a total of six treatments. The data collected from the first batch of planting showed that the difference in respect of the treatments was not statistically significant. Seedlings raised from selected nuts gathered from non-prepotent palms had significantly more height than all other treatments.

It has already been established in arecanut that the high yield of a particular palm is due to its high set, the number of female flowers and set being independent of each other. The conditions under which such a high set is obtained will be of interest from the breeding point of view. The distribution of female flowers in the rachis as one of the factors involved in this was taken up for study. Sixty progenies of mother palms were being studied.

B. 7. Improvement by Mass-pedigree selection

The Mass-pedigree selection programme finalised in the previous year was further examined and a crossing programme using the principle of poly-cross was included at the stage of production of nuts meant for second generation. Seedlings raised from sixteen selected palms were transplanted to the secondary nursery for continuing the selection procedures along with the two controls. Seednuts from the above palms were also sent to the Regional Stations for building up genetically superior materials for distribution and further improvements. During the year 633 seed nuts were sent to Peechi (Central Kerala) and 1223 seednuts to Mohitnagar (West Bengal.)

B. 9. Structure and development of fruits in arecanut under high and low altitudes.

Ripe nuts from higher altitudes are found to shrink when they are dried. A casual study of nuts collected from different elevations taken up some time earlier had shown wide variability in shrinkage. The development of kernel appeared to be highly influenced by climatic conditions prevailing in these elevations. The present study was, therefore, initiated to find out the development of endosperm and the related phenomena that affect the germination of nuts for fixing up the altitude up to which arecanut can be successfully grown for the preparation of *Chali*.

A survey was taken up during the year under report to assess the availability of material at different elevations existing in Coorg and South Kanara Districts. The survey showed that adequate number of palms will be available up to an altitude of 1200 m. A few samples were also collected from these altitudes both for drying and germination trials.

B. 10. Cytological and anatomical studies of types, species and hybrids of arecanut

Standardisation of sampling technique for the study of epidermal pattern of leaf was taken up and it was observed that the top leaflet of the 7th leaf was a representative sample for the study. Four palms in each of the thirteen introductions and the local planted in 1961 were studied with respect to the following characters.

1. Length of guard cells
2. Breadth of guard cells
3. Length of stomatal pore
4. Length of epidermal cells
5. Breadth of epidermal cells
6. Number of stomata per unit area, and
7. Number of epidermal cells per unit area.

The data were a nalysed and the results showed that there was significant difference between the types in respect of stomatal index, length of stomatal pore, length and breadth of guard cells, number of epidermal cells per unit area and number of stomata per unit area. These characters will be utilised for working out the genetic distance between these exotic types.

B. 11. Studies on fruit setting and shedding

Yield in arecanut has been found to be affected by low fruit–set as well as by subsequent shedding of the set fruits. Under South Kanara conditions only about 30 per cent of the female flowers get

set. The problem was being investigated from various angles and it was observed that in a number of the shed female flowers pollination had not taken place. In certain others fungus as well as insect associations were also observed in the case of both buttons and tender nuts that are shed. Studies on the effect of some of the hormones such as gibberellic acid, N.A.A. etc., in increasing the fruit-set had given encouraging results. Assisting the pollination also had helped in enhancing the set. A comprehensive trial was, therefore, taken up during the year. The results are given in Table 6.

TABLE 6

Influence of different treatments on fruit-set

Treatments	Percentage of fruit-set*
1. Open pollination (control)	6.38
2. Assisted pollination with pollen suspended in 0.5% sucrose + 0.1% agar medium	16.39
3. Boric acid alone (100 ppm)	7.94
4. Boric acid (100 ppm) in the medium as in treatment 2 + pollen	13.28
5. Gibberellic acid alone (500 ppm)	10.07
6. Gibberellic acid alone (2000 ppm)	9.47
7. Gibberellic acid (500 ppm) in the medium as in treatment 2 + pollen	22.78
S. E. per plot	4.62
Overall mean	12.40
C. V. (%)	37.25
S. E. of treatment mean	1.74
C. D. (P = 0.05)	5.35

*The low set is due to the off-season nature

From the above table it is evident that an increase of 10 per cent fruit-set can be obtained by assisting the pollination. It was also observed that this set could be increased further by another 6 per cent if gibberellic acid at 500 ppm was dded to the medium. The increase obtained in both the above cases was significantly more than the control. Since the treatments which had given the maximum set were not economic, the study is being continued using low setters.

Studies on this problem were also in progress at the Regional Station at Kahikuchi. Spraying trials were taken up using fungicides (1% Bordeaux mixture and wettable copper 50%) and insecticides (D.D.T. 50% and Endrin) alone and in combinations. Two rounds of spray were

given, one at the peak flowering season and the other after one month. The results showed that all the treatments except control have given higher percentage of fruit-set and number of nuts harvested. Spraying of 1% Bordeaux mixture + Endrin (125 ml in 100 litres of Bordeaux mixture) in two rounds gave 16.27 per cent increase in fruit-set over the control. At Hirehalli a similar study was conducted using different fungicides and hormones. The results indicated that captan was promising.

B. 12. Inducing mutations in arecanut

With a view to increasing genetic variability in the existing material seed arecanuts were treated with following mutagenic agents.

a) By irradiation of seednuts (thermal and pile neutrons, X-ray and Gamma ray)

Seedlings obtained from the irradiated seednuts were planted in the main field during 1963. It is observed that one of the plants under the treatment 1×10^{12} 3 hrs. 42 m. has very poor growth as compared to others.

A total of 200 seednuts were irradiated at the Gamma Cell of the Indian Agricultural Research Institute during 1955–56. The irradiated nuts were sown and seedlings planted in the main field both at the Central Station and at the Regional Station, Palode. These palms are under study.

b) By chemicals

Sprouts were treated with colchicine and the seedlings obtained were planted in the field. These palms have started flowering and they are under observation.

(c) RESEARCHES CONTEMPLATED

Cytoanatomical studies of the arecanut endosperm in relation to its development under high and low altitudes have been programmed. A crossing programme involving indigenous and exotic types to find out the xenia effect will also be undertaken.

Programme of work for 1968

Number and name of the project	Venue of work
B.1. Introduction and maintenance of indigenous and exotic species and types of areca for selection and hybridisation	Vittal, Peechi, Hirehalli, Mohitnagar, Kahikuchi and Palode
B.2. Survey of arecanut gardens to assess the genetic variation and selection of common cultivars	Vittal, Peechi, Hirehalli, Mohitnagar, Kahikuchi and Palode

B.3.	Studies on the performance of progenies of known mother palms and the mother palm progeny relationship	Peechi and Hirehalli
B.4.	Production of inbred lines of distinct types	Vittal
B.5.	Hybridisation between exotic and indigenous types and species	Vittal
B.6.	Efficiency of phenotypic selection of mother palms, seednuts and seedlings	Vittal and Peechi
B.7.	Improvement by Mass-pedigree selection	Vittal, Mohitnagar and Peechi
B.8.	Floral initiation	Vittal
B.9.	Structure and development of fruits in arecanut under high and low altitudes	Vittal and Kahikuchi
B.10	Cytological and anatomical studies of types, species and hybrids of arecanut	Vittal
B.11.	Studies on fruit setting and shedding	Vittal, Mohitnagar, Peechi, Hirehalli, Kahikuchi and Palode
B.12	Inducing mutation in arecanut by (a) irradiation of seednuts (Thermal and pile neutrons, X-ray and Gamma rays), (b) Chemicals, and (c) use of irradiated pollen	Vittal

AGRONOMY

(K. Shama Bhat, K. Narasimha Murthy, M. Sannamarappa, R. K. Bhattacharya and C. S. Abraham)

SUMMARY OF SALIENT FINDINGS

Planting seedlings up to two years in age whether directly or after transplanting in the nursery did not affect their initial flowering. Spacing given to palms in the main field was found to influence sun-scorching of stems, leaves shed, spadices and female flowers produced and yield. Maximum scorching of 54 per cent was seen in palms spaced at 3.6mX3.6m whereas it ranged from zero to 8.6 per cent in palms spaced closely. The number of leaves shed and spadices and female flowers produced invariably increased progressively with increase in spacing. At one of the centres the trees spaced at 1.8 m X 1.8 m had a mean of 890 female flowers per tree as against 1630 in trees spaced at 3.6 m X 3.6 m. The maximum number and weight of fruits harvested per unit area were found to centre round spacings of 2.7 m X 2.7 m and 3.6 m X 1.8 m at Vittal and Peechi respectively. Irrigation was found to have significant influence on growth and flowering of arecanut palms. At one of the centres 91.1 to 100 per cent of the palms flowered under irrigated conditions as against 48.9 to 75.6 per cent under unirrigated conditions. Depth of planting was also found to have significant influence on the flowering of the palms. Palms planted at 90 cm had significantly more percentage of them flowered than those planted either at 30 cm or 60 cm depths. The first set of quinquennial observations on the growth features of arecanut palms recorded in the experimental garden where banana is being tried as intercrop showed no significant difference between the palms in plots with and without banana. In one of the centres where other intercrops like elephant-foot-yam, colocasia, pineapple and banana were grown with arecanut, the intercrops did not have any adverse effect on the main crop of arecanut. Elephant-foot-yam gave the maximum net return of Rs. 1,516/- per hectare in addition to the income from arecanut. In the mixed garden of arecanut and cacao, the latter yielded a mean of 10.6 pods per tree during the third year of growth. The growth of arecanut was normal. Under

rain-fed conditions (Palode, S. Kerala) the initial performance of palms under clean cultivation and manuring was significantly superior to either cover cropping and manuring or no cultivation and no manuring. In the N P K manurial experiment, palms receiving nitrogen at N_1 level (i. e., N at 50 g/tree) and green leaf at G_2 level (i. e., 13.6 kg/tree) recorded significantly higher yield at one centre than plots receiving no nitrogen or green leaf respectively. In another centre potash was also found to affect the yield significantly, palms receiving potash at 140 g per tree recording significantly more yield than those receiving no potash. In Palode area where the palms are not normally irrigated the influence of application of N P K with or without micro-nutrients but with irrigation was found to be superior to the application of the same nutrients without irrigation.

(a) RESEARCHES COMPLETED

A. 6. Intercropping in arecanut

The practice of growing intercrops like banana, tapioca, arrow-root, ginger, elephant-foot-yam, colocasia, etc., is in vogue in almost all the arecanut growing tracts of the country. Informations about the economics of cultivating these intercrops, effect of the same on the main crop of arecanut and the proper stage of growth of the arecanut plantations at which these crops can be grown are not available. Experiments were, therefore, started at Central and Regional Stations to elucidate information on the above aspects of the intercropping.

A trial was initiated at Peechi in 1964, on a 5X5 Latin square design with four common food crops of the tract viz., banana, colocasia, pineapple and elephant-foot-yam. Statistical analysis of data gathered for the past 3 years revealed that growing any one of the intercrops did not have any detrimental effect on the main crop. The yield obtained, cost of cultivation and net income per hectare of the different intercrops are given in Table 1.

TABLE 1

Economics of raising different intercrops (per ha)

Intercrop	Cost of cultivation (Rs)	Yield obtained (kg)	Net profit (Rs)
1. Banana	712	4,133	177
2. Colocasia	663	2,435	nil
3. Pineapple	498	1,676	nil
4. Elephant-foot-yam	945	12,177	1,516

It can be seen that elephant-foot-yam fetched the maximum net profit. Since the Regional Arecanut Research Station, Peechi is situated in a place which is representative of the conditions prevailing in Central and Northern Kerala, having an area of about 35,000 hectare under arecanut the above finding is of immediate potential value.

(b) RESEARCHES IN HAND

A. 1. Determination of optimum age of transplanting seedlings cum sowing *in situ vs.* trnsplanting of single, double and treble transplanted seedlings

Seedlings of different ages are used for the main field planting in different tracts. The practice of directly sowing the nuts *in situ* as well as transplanting seedlings in nurseries themselves prior to the main field planting are also in vogue. An observational trial to study these aspects was laid out at Central Station with the following eight treatments:

1. Directly sowing seednuts in the main field
2. Transplanting one year old seedlings
3. Transplanting two-year old seedlings
4. Transplanting three-year old seedlings
5. Transplanting four-year old seedlings
6. Transplanting two-year old seeelings which had been transplanted once in the nursery.
7. Transplanting three-year old seedlings which had been transplanted twice in the nursery.
8. Transplanting four-year old seedlings which had been transplanted thrice in the nursery.

The trial was commenced in 1961. Observations made in the previous years showed that palms planted in the field earlier are more vigorous than those of equal age but retained in the nursery for longer durations and then transplanted to the field. Palms in most of the treatments flowered during the year. It was generally observed that planting seedlings up to two years in age whether directly or after transplanting in the nursery does not affect their initial flowering. Seedlings transplanted beyond two years of age were found to be late in their flowering.

A similar trial with six treatments was in progress at Kahikuchi since 1963-64. Observations made on the growth features of the palms revealed that palms which have been planted in the field when young (18 or 30 months old) are more vigorous than those which have been planted when they are 42 months old.

A.2. Determination of optimum spacing in the main field

This experiment having six spacings viz., 1.8 m X 1.8 m, 2.7 m X 1.8 m, 3.6 m X 1.8 m, 2.7 m X 2.7 m, 2.7 m X 3.6 m and 3.6 m X 3.6 m as treatments laid out on a randomised replicated design was in progress since 1958. The, trees commenced flowering in 1962-63. Studies on the following aspects were continued to be made in the experimental garden.

a) Spacing and sunscorch: The wider spacing of 3.6 m X 3.6 m had 54.0 per cent of the palms affected by sun-scorch. Percentage of plams affected by sun-scorch in the other spacings ranged between 0 to 8.57. Similar result had been obtained during the previous year also.

b) Spacing and inflorescence production: The number of leaves shed, spadices produced and percentage of spadices to leaves shed progressively increased with increase in spacing. Trees spaced at 1.8 m X 1.8 m had significantly less number (7.05) of leaves shed, spadices (4.75) produced and percentage of spadices (67.53) per tree than others. However, the number of leaves shed and spadices produced per unit area were maximum in the closely spaced plots of 1.8 m X 1.8 m and minimum in the widest spacing of 3.6 m X 3.6 m.

c) Spacing and number of female flowers produced and set: The number of female flowers produced and percentage of set were also found to show significant variation. While the trees spaced at 1.8 m X 1.8 m had 890 flowers per tree and 7.94 per cent set, palms spaced at 3.6 m X 3.6 m had the maximum of 1630 female flowers per tree and palms spaced at 3.6 m X 2.7 m the maximum set of 26.33.

d) Spacing and yield: Though the yield difference between treatments was not significant, the maximum number and wet weight of fruits harvested per plot were obtained from trees spaced at 2.7 m X 2.7 m. The cumulative yield of fruits harvested per plot since 1963 also continued to be maximum in the same spacing. The net profit per hectare per year of the garden was also maximum (Rs. 7,308.62) when the trees are spaced at 2.7 m X 2.7 m. A similar but significantly different result was obtained during the previous year. The mean data on yield and economics of treatment are given in Table 2.

TABLE 2:
Yield and economics under different spacings

Spacing	Yield/ha. – cumulative for 4 years – (No. in thousands)	Economics (mean net profit in Rupees per ha. per year
1.8 m X 1.8 m	503.35	2144.31
2.7 m X 1.8 m	652.41	5155.80
3.6 m X 1.8 m	692.84	6138.53
2.7 m X 2.7 m	756.44	7308.62
3.6 m X 2.7 m	670.24	6234.32
3.6 m X 3.6 m	503.24	4175.65

e) *Spacing and quality of produce:* The yield of *Chali* (dry kernel) and its quality were assessed from representative harvests. The results showed that spacing had no effect on the above. Similar result was obtained during the previous year also.

The second set of quinquennial observations on the growth features of the individual palms recorded during October, 1967 revealed that trees spaced at 1.8 m X 1.8 m had significantly less girth at the last exposed node and significantly less number of leaves than the rest of the treatments.

A similar trial was also running at the Regional Stations at Peechi, Hirehalli and Kahikuchi. At Peechi, where the experiment was laid out in 1960, trees spaced at 1.8 m X 1.8 m had significantly less number of leaves shed, spadices produced and percentage of spadices to leaves shed. With regard to yield (number and weight), it was significantly more in plots with 1.8 m X 3.6 m and 2.7 m X 2.7 m spacings than that obtained from 1.8 mX1.8 m, 2.7 m X 3.6 m and 3.6 m X 3.6 m spacings. At Kahikuchi where the trees had commenced flowering, palms spaced at 1.8 m X 1.8 m had significantly more number of female flowers than the rest. At Hirehalli, leaf fall in palms spaced at 3.6 m X 3.6 m and 3.6 m X 2.7 m was significantly more than that in 1.8 m X 1.8 m and 1.8 m X 2.7 m.

A. 3. Effect of different spacings and methods of layout on the incidence of sun-scorch on arecanut palm

Arecanut palms are highly susceptible to sun-scorch particularly in situations where the palms are exposed to the southern and south-western sun. In order to find out whether method of aligning the garden and spacing have any bearing with scorching, an observational trial was planted in 1960 with three spacings of 2.4 m X 2.4 m square, 2.7 m X 2.7 m square and 3.6 m X 3.6 m quincunx, each aligned in north-south direction and at an

angle of 20° to north-south. A count of the palms showing sun-scorch symptoms made in December, 1967 showed that the percentage of palms affected by sun-scorch was less in the plot spaced at 3.6 m X 3.6 m quincunx, north-south as compared to the same spacing aligned at 20° to north-south. This is in conformity with the previous years' observations. Results obtained in other treatments were inconsistent.

A. 4. Effect of different intervals of irrigation at different depths of planting arecanut seedlings

The depth at which arecanut seedlings are planted in the main field and the intervals of irrigation vary considerably from tract to tract and with different soil conditions. This experiment was, therefore, initiated to determine the effect of depth of planting areca seedlings in the main field and the intervals of irrigations on yield under conditions prevailing in the different regions. At Peechi, the experiment was initiated in 1962 adopting a 4X3X5 split plot design with four intervals of irrigations (viz., no irrigation, irrigation once in 3, 6 and 9 days) and three depths of planting (viz., 30 cm 60 cm and 90 cm). Majority of the palms in the garden flowered during the year. The data on the percentage of palms flowered are given below in Table 3.

TABLE 3

Percentage of palms flowered in relation to depth of planting and intervals of irrigation

Irrigation	Depth of planting			Mean
	30 cm	60 cm	90 cm	
No irrigation	48.90	64.44	75.56	62.97
Irrigation once in three days	93.34	95.56	100.00	96.30
Irrigation once in six days	91.12	95.56	100.00	95.56
Irrigation once in nine days	95.56	91.12	100.00	95.56
Mean	82.23	86.67	93.69	—

S. E. per main plot	9.50	S. E. for differences between	
S. E. per sub plot	10.15	1) irrigation mean	2.45
Overall mean	87.60	2) depth mean	3.21
C. V. (%) main plot	10.84	C. D. for irrigation mean	5.34
C. V. (%) sub-plot	11.58	C. D. for depth mean	6.55

It can be observed from the above that in all the irrigation treatments there is significantly more percentage of palms flowered than in no irrigation treatment. The mean percentage of palms flowered under no irrigation ranged from 48.90 to 75.56 whereas under irrigation treatments the same

ranged from 91.12 to 100.00. As regards planting depths, plants at 90 cm had significantly more percentage of palms flowered than the other two depths of planting. It is also interesting to observe that under no irrigation, the palms planted at 90 cm had a much higher percentage (75.56) of palms flowered than those planted at 60 cm and 30 cm depths. The interaction is, however, not significant. The first set of quinquennial observations on growth features of the palms was recorded. It was observed that palms under no irrigation had significantly lesser girth at collar, height and number of nodes than those which had irrigations and significantly lesser girth at permanent mark than those irrigated once in 3 days. Plots irrigated once in 3 days had significantly more girth at collar, girth at permanent mark and number of nodes than the rest of the treatments. Though plants at 90 cm and 60 cm depths had significantly less girth at collar, palms planted at 90 cm depth had significantly more height and number of nodes than those planted at 30 cm and 60 cm depths.

At the Central Station the experiment was laid out in 1966 on a 4 X 3 X 5 strip plot design with four intervals of irrigation (viz., 5, 10, 15 and 20 days) and three depths of planting (viz., 30 cm, 60 cm and 90 cm). The irrigation treatment was commenced from November, 1967. Annual growth measurements of the palms made revealed that seedlings planted at 30 cm depth had significantly lesser height than those planted at 60 cm and 90 cm depths. Considering the number of leaves produced, girth and height it may be said that deeper planting helps for better growth of seedlings

At Kahikuchi where 15, 30 and 45 cm depths have been adopted seedlings planted at 15 cm and 30 cm depths had significantly more height and number of nodes than those planted at 45 cm depth. Regarding number of leaves, seedlings planted at 15 cm had significantly more leaves than those planted at 45 cm depth. A similar experiment was also in progress at Hirehalli.

A. 6. Intercropping experiment

a) Banana: Banana is the most common food crop intercropped in arecanut gardens in all arecanut growing tracts. In order to assess the effect of growing banana as an intercrop in arecanut gardens as well as to find out the optimum number of plants and the stage at which the former can be raised with the latter, an experiment on an 8 X 4 randomised block design with the following treatments was laid out at the Central Station in 1963.

1. No banana throughout the period of experiment (i.e., pure plantation of arecanut).
2. Banana as intercrop throughout the period of experiment at full level.
3. Banana up to the end of third year at full level and no banana thereafter.
4. Banana up to the end of third year at full level and at reduced level for the rest of the period of experiment.
5. Banana up to the end of third year at full level and at reduced level till the end of sixth year and no banana thereafter.
6. Banana up to the end of sixth year at full level and no banana thereafter.
7. Banana up to the end of sixth year at full level and at reduced level thereafter for the rest of the period.
8 Banana up to the end of sixth year at full level and at reduced level till the end of tenth year and no banana thereafter.

Note: The third year corresponds to the period when majority of the trees would have formed distinct nodes. The sixth year corresponds to the period when more than 50 per cent of the palms would have flowered. Tenth year corresponds to the attainment of the full bearing capacity.

Both the crops were given the normal cultural and manurial operations as per the schedule for each crop. The experiment was running in the second stage (i.e., the period covering 4th to 6th year). The first set of quinquennial observation on the growth features of the arecanut palms made in 1967 showed no significant difference between the palms in the different treatment plots. The growth features studied include such factors like height of palms, girth at permanent mark and at the last exposed node, internodal distance at the above points, total number of nodes, number of leaves etc. There was an increase in the number of trees flowered during the year and the percentage ranged from zero to ten in the different treatment plots.

A similar experiment as above with only five treatments superimposed in a three-year old garden was running at Kahikuchi since 1963-64. The growth measurement of arecanut palms recorded showed that banana had no adverse effect on the growth of the former. A similar experiment at Peechi had to be dropped as the majority of the banana plants was affected by bunchy top.

b) Other crops: In order to explore the possibility of growing certain inter and associate crops in arecanut gardens without detriment to the

arecanut crop, trials with various crops were in progress at the Regional Arecanut Research Station, Peechi. Earlier trials had indicated that elephant-foot-yam *(Amorphophallus campanulatus)* is the most profitable intercrop that can be grown in arecanut garden. During the year the trial has been relaid with two new additions viz., pepper and ginger and deleting colocasia *(Colocasia antiquorum)* and banana. These intercrops were found to have no significant effect either on the yield or growth of the arecanut palms.

A similar trial with intercrops of banana, pineapple, guinea grass, ginger and betel vine was in progress at Kahikuchi. It was observed that the mean number of spadices produced per palm was significantly more in plots with guinea grass than in plots with banana, pineapple and control.

A. 7. Mixed cropping experiments

a) Arecanut and coconut: Arecanut and coconut are found grown as mixed plantations in certain areas. To assess the desirability of such a practice as against raising them as pure crops, an observation trial with two treatments viz., (i) arecanut and coconut as mixed crops and (ii) arecanut as pure crop, repeated twice was laid out at the Central Station during 1964. The coconut seedlings were planted in 1964 at a spacing of 8.1 m X 8.1 m and the arecanut in 1965 at 2.7 m X 2.7 m. The growth of both arecanut and coconut palms was satisfactory.

Similar trials were also in progress at the Regional Stations, Kahikuchi and Palode.

b) Arecanut and cacao: A mixed garden of arecanut and cacao (Criollo variety) was planted at the Central Station in 1964 as an observational trial with (i) arecanut and cacao at 50:50, (ii) areca as pure crop and (iii) cacao as border to areca garden. The first crop of cacao was harvested during the year. Seventy-five per cent of the cacao trees in the plot, where areca and cacao are at 50:50, yielded fruits with a mean of 10.6 pods per tree, the range in pod production being 3 to 35. Harvesting of the second crop was commenced towards the close of the year. The pods obtained were used for test fermentation and drying. The beans after separation were fermented in a box with perforated bottom for 48 hours and then dried in the open sun. About 40 pods were found to give one kg of dry beans. The cacao trees planted as border crop suffered due to sun-scorch and did not bear fruits during the first season. The growth of areca palms appears normal in all the plots.

A. 8. Effect of different methods of intercultivation on the productivity of palms

A cultural experiment with four treatments and six replications was initiated at the Regional Station, Hirehalli. The treatments consisted of (i) scything grass and weeds twice a year (December and June), (ii) digging with mammuty-fork twice a year (December and June), (iii) digging with mammuty-fork once a year in December followed by scything grass and weeds in June and (iv) scything grass and weeds twice a year as in treatment (i) and digging once in two years.

A similar trial as above with four treatments viz., (i) no intercultivation, (ii) digging once a year, (iii) digging twice a year and (iv) digging once in two years was also laid out at the Regional Station, Peechi.

The experiment to study the different methods of raising arecanut gardens on hill slopes laid out in 1961–62 at Palode with three systems of planting viz., (i) planting on terraces made along the contour, (ii) planting on terraces made at the site of planting and (iii) planting on slopes not taking into account the contour and with three sub-treatments viz., (i) no cultivation, no manuring, (ii) clean cultivation and manuring and (iii) permanent cover cropping and manuring, was continued. More palms flowered during the year. It was observed that planting along slopes significantly increased the inflorescences per tree (3.86) as compared to planting on terraces (2.69/tree). The performance of palms under clean cultivation and manuring was also significantly superior to cover croping and manuring or no cultivation and no manuring

A. 9. N P K manurial experiment

This experiment was laid out both at Central and Regional Stations to find out the N P K and green leaf requirements of arecanut palm under varied soil and climatic conditions. It was laid out in 1961 at Vittal on a 3^4 confounded factorial design as a single replication. The treatments consisted of 0, 25 and 50 kg of nitrogen (N), 0, 20 and 40 kg of phosphoric acid (P), 0, 35 and 70 kg of potash (K) and 0, 3400 and 6800 kg of green leaf (G) for 500 palms. More palms flowered and the first crop of the garden was harvested during the year. Data on leaf-fall, production of spadices, number and weight of nuts harvested and percentage of palms from which harvests were made were recorded. The results showed that the main effect of nitrogen was significant on leaf-fall, production of spadices, yield (number and weight of nuts) and percentage of palms that came for harvest. Palms receiving 25 kg nitrogen per 500 palms recorded significantly higher yield than those not receiving any nitrogen. The main effect of phosphoric

acid and potash was significant with regard to leaf-fall alone. Like nitrogen the main effect of green leaf was significant on all characters examined. Application of green leaf at 6800 kg per 500 palms gave significantly higher yield than plots receiving no leaf. With regard to interactions only nitrogen and potash, nitrogen and leaf, phosphoric acid and potash, phosphoric acid and green leaf and potash and leaf were significant. With regard to yield $P_0 K_2$, $P_1 K_0$ and $P_1 K_1$ had given significantly more number of nuts as well as weight than $P_0 K_0$. In respect of percentage of spadices to leaf-fall $P_2 K_0$, $P_0 K_2$, and $P_1 K_0$ were significantly better than $P_0 K_0$.

Observations on similar lines were also made at Peechi. Unlike at Vittal none of the main effects or interactions showed any significant difference as regards the mean leaf-fall per tree. But in the case of mean spadices produced per tree all interactions and main effects except N and P were significant. As regards percentage of spadices produced to leaf fall all the main effects as well as their interactions were significant. Regarding yield main effects of N, K and G and interactions of N P and P G were significant. N_1 and N_2 had given significantly more number and wet weight of fruits harvested than N_0. As regards potash, K_2 gave significantly more yield (number and weight) than K_0. Similarly G_2 gave significantly more wet weight than G_1 and G_0. Interactions of $N_2 P_0$ and $N_1 P_2$ were significantly better than most of the other combinations of N and P. It was also observed that in the absence of leaf, treatment differences between different levels of phosphoric acid were significant

The palms under N P K manurial experiment planted at Hirehalli in 1962 have not yet flowered. Observations on growth characters of the palms did not show any significant treatment difference. A similar experiment laid out at Kahikuchi in 1962 was also in progress. The trees have flowered. Observations made on leaf fall, number of spadices produced and percentage of spadices to leaf-fall revealed that only the main effect of N is significant.

At Mohitnagar the entire experiment has been replanted with the addition of lime as a sub-plot.

The experiment laid out at Palode to determine the influence of application of macro and micro nutrients with and without irrigation showed during the first year of bearing that N P K with or without micro nutrients but with irrigation is superior to N P K with or without micro nutrients but without irrigation. There was no significant difference between N P K + irrigation and N P K + micro nutrients + irrigation. In this connection it may be mentioned that in Palode area where the experiment is laid out the cultivators normally do not irrigate the arecanut gardens. The mean yield (number of nuts) per plot for different treatments is given in Table 4.

TABLE 4:

Yield of nuts from different treatments

	Treatment	No. of nuts/plot
1.	No cultivation, no manuring	0
2.	N P K with irrigation	307.3
3.	N P K without irrigation	91.8
4.	N P K + Micro nutrients with irrigation	489.4
5.	— do — without irrigation	146.8
	S. E./plot	150.73
	Overall mean	207.00
	C. V. (%)	72.82
	S. E. of treatment mean	67.29
	C. D. (P=0.05)	201.73

Another experiment laid out at Palode to determine the effect of application of N P K with and without lime revealed no significant influence of lime over plots receiving no lime. The garden was planted in 1961 and the treatments were superimposed in 1964.

A. 10. Effect of applying fertilizers to supply N P K in organic and inorgamic forms on palm performance

The experiment was programmed to determine whether palms receiving chemical fertilizers will have any adverse effect if changed over to organic manures and *vice versa*. The treatments were superimposed in a six-year old garden at Central Station, Vittal, which was receiving only cattle manure and green leaf throughout uniformly. The first dose of fertilizers as per treatments was applied in 1963-64. The treatments consist of (i) N, P and K (25, 25 and 40 kg respectively for 500 palms per year) in organic form from 6th to 15th year, (ii) N, P and K in inorganic form from 6th to 15th year, (iii) N, P and K in organic form from 6th to 10th year and then in inorganic form till 15th year and (iv) N, P and K in inorganic form from 6th to 10th year and then in organic form till 15th year. The yield data for the current year also did not show any significant difference between the two treatments compared.

A. 11. Studies on placement and fractional application of fertilizers

The experiment was kept in abeyance until such time information on the N P K requirement of the crop is available from the N P K manurial experiment in progress.

A. 12. Harvesting trials

a) Season-wise variation in quality of produce and (b) quality of produce as influenced by degree of maturity

The trial was continued at Peechi with a view to investigating the difference in quality of processed tender arecanuts harvested during different seasons and at known maturity levels. Fresh inflorescences were selected and their date of opening noted for taking up harvests at known maturity intervals.

A. 13. Root studies of arecanut palm of different ages and under different soil conditions

A review of the work done so far was made and it was decided to take up the study in the low-lying areas of Vittal and under non-irrigated conditions prevailing at Palode.

A. 14. Crop weather study

Weather data in respect of rain-fall, temperature, humidity, etc., were recorded at the Central and Regional Stations. The data on rain fall and temperature are given in Table 5 (P.39).

(c) RESEARCHES CONTEMPLATED

Investigations on floral abortion of arecanut made in the Botany Section had shown that this character was highly influenced by environmental factors. Studies on the time of application of fertilizers that had been contemplated were, therefore, proposed to be taken up on a priority basis.

Programme of work for 1968

Number and name of the project	Venue of work
A. 1. Determination of optimum age of transplanting seedlings-cum-sowing *in situ vs.* transplanting of single, double and treble transplanted seedlings	Vittal and Kahikuchi
A. 2. Determination of optimum spacing in the main field	Vittal, Peechi, Hirehalli and Kahikuchi
A. 3. Effect of different methods of lay-out on the incidence of sun–scorch on arecanut palms	Vittal
A. 4. Effect of different intervals of irrigation at different depths of planting arecanut	Peechi, Vittal, Hirehalli, Kahikuchi and Mohitnagar
A. 5. Investigation on different types of areca under rainfed and irrigated conditions	Vittal and Mohitnagar

A. 6.	Intercropping experiments a) banana b) other crops	Vittal, Kahikuchi, Peechi, Hirehalli and Palode
A. 7.	Mixed cropping experiments a) coconut b) cacao	Kahikuchi, Vittal and Palode
A. 8.	Effect of different methods of inter-cultivation on the productivity of palms	Hirehalli, Peechi and Mohitnagar
A. 9.	N P K manurial experiment	Vittal, Peechi, Hirehalli, Kahikuchi, Mohitnagar and Palode
A 10.	Effect of applying fertilizers to supply N P K in organic and inorganic forms on palm performance	Vittal
A.11.	Studies on placement and fractional application of fertilizers	Vittal and Peechi
A.12.	Harvesting trials – a) season-wise variation in quality of produce b) quality of produce as influenced by degree of maturity	Peechi
A.13.	Root studies of arecanut palm	Vittal and Palode
A.14.	Crop weather study	Vittal, Peechi, Hirehalli, Kahikuchi, Mohitnagar and Palode

TABLE 5:

Rainfall and temperature data for the year 1967

Month	VITTAL				PEECHI				HIREHALLI				KAHIKUCHI				MOHITNAGAR				PALODE			
	Rain-fall mm.	Mean R.F. for previous 5 yrs mm.	Temperature °C Max.	Min.	Rain-fall mm.	Mean R.F. for previous 5 yrs mm.	Temperature °C Max.	Min.	Rain-fall mm.	Mean R.F. for previous 5 yrs mm.	Temperature °C Max.	Min.	Rain-fall mm.	Mean R.F. for previous 5 yrs mm.	Temperature °C Max.	Min.	Rain-fall mm.	Mean R.F. for previous 5 yrs mm.	Temperature °C Max.	Min.	Rain-fall mm.	Mean R.F. for previous 5 yrs mm.	Temperature °C Max.	Min.
January	4.6	0.49	35.0	12.2	—	1.00	32.4	19.1	17.0	0.96	30.0	Not available	7.1	7.36	24.6	11.3	—	5.00	28.5	4.0	64.5	41.54	34.0	14.5
February	—	—	38.0	13.0	—	23.94	32.6	19.1	—	2.30	33.5	-do-	13.2	14.44	26.8	11.6	—	7.20	30.9	6.2	—	52.92	37.0	13.0
March	—	2.21	37.5	14.8	27.0	31.10	32.3	23.8	—	4.62	34.5	-do-	119.1	46.51	27.5	15.0	166.8	18.20	32.0	8.4	83.2	152.02	37.0	17.0
April	14.2	32.98	38.0	20.5	29.0	30.68	34.6	24.5	72.6	74.94	36.5	16.0	146.7	149.39	30.4	16.8	35.8	118.60	34.7	11.0	187.5	245.01	36.5	20.0
May	142.8	239.35	37.0	20.5	283.4	184.72	33.5	23.9	269.2	108.16	36.5	16.0	145.0	257.61	30.5	21.8	288.2	293.20	35.7	18.7	148.9	197.78	35.0	12.5
June	827.9	857.63	34.0	20.0	529.4	497.90	30.8	22.1	98.9	111.90	33.5	17.5	131.3	370.13	31.0	24.1	1012.1	472.00	33.7	21.0	479.0	248.78	35.0	20.5
July	1497.3	1205.96	30.5	19.2	745.3	743.38	29.3	21.2	448.9	131.32	30.5	17.0	206.6	234.59	31.6	25.0	891.9	803.60	34.2	23.0	334.9	422.54	31.5	21.0
August	974.2	813.66	30.5	19.0	606.6	386.10	29.6	21.4	124.0	212.16	31.0	18.5	247.5	290.38	32.7	24.2	249.8	901.70	34.5	22.9	242.6	211.70	31.5	19.0
September	211.4	349.63	31.5	19.5	66.8	251.02	30.7	21.7	35.7	254.42	31.0	15.5	311.5	115.15	31.8	24.5	421.4	494.00	33.9	21.7	159.4	308.92	34.5	20.5
October	97.6	203.81	35.0	17.5	142.8	348.12	31.6	21.6	103.2	200.13	30.5	11.0	18.9	39.82	30.2	20.3	231.4	46.40	32.5	14.4	318.4	420.84	32.9	19.0
November	80.2	81.77	34.5	13.5	70.8	105.96	31.6	20.5	9.6	141.02	29.5	10.0	48.0	16.18	26.7	13.6	—	4.90	30.4	9.2	173.5	226.14	34.5	15.5
December	4.4	32.66	35.0	14.5	33.6	48.64	31.7	21.2	39.5	26.58	29.0	10.0	1.0	6.83	24.3	11.3	—	2.40	27.2	7.2	18.4	140.12	34.0	17.0
Total	**3854.6**	**3820.15**			**2534.7**	**2652.56**			**1218.6**	**1268.51**			**1395.9**	**1548.39**			**3297.4**	**3167.20**			**2210.3**	**2668.31**		

STATISTICS

(P. R. Ramachander)

SUMMARY OF SALIENT FINDINGS

Two samples of 40 kg each of green nuts with husk drawn from a given lot at random were found to be sufficient for determining the percentage of out-turn of "Choor". *The transmitting ability of yield of prepotent palms seems to be due to the transmitability of percentage of set. The percentage of set which has correlation with yield was also found to have relatively higher heritability than yield and hence could be used as a selection criterion of mother palms with advantage. Results on biometrical studies indicated that the 20 per cent shedding that takes place after setting was not genetically controlled and hence can be reduced by providing the optimum conditions of growth. Mean weight of nut which has negative correlation with yield was found not to set any limitation for improvement in yield.*

(a) RESEARCHES COMPLETED

S. 1. Refinement of experimental technique

Determination of sample size to find percentage out turn of **"Choor"** ***(tender cured nut) of a given lot (In collaboration with Regional Arecanut Research Station, Peechi)***

Final comparison of treatments in arecanut has to be done based on the yield of cured produce from each treatment. Even though *Chali* (ripe nuts dried and husked) is the finished product in majority of the areas, in certain tracts of Kerala, interior Mysore and Madras tendernut harvest and processing are in vogue. One of the important trade varieties of tendernut in Kerala is *Choor*. A sampling technique for estimation of percentage of out-turn of *Choor* from a given lot was, therefore, worked out. For this purpose 96 lots each weighing 10 kg (green weight with husk) were cured separately and percentage of out-turn of *Choor* determined. By grouping randomly, samples of greater weight were obtained. The coefficient of variation in each case and also the minimum number of samples of a particular size required to give estimates falling within 5 per cent limit of actual value 95 per cent of times was worked out. The results showed that six samples of 10 kg each will be the lowest minimum quantity to be sampled. However, taking into consideration the cost of curing, two samples of 40 kg each was fixed as the best sample size for the above purpose.

S. 2. Correlation, heritability and causation studies

Transmitting ability of different yield attributes: It had been observed earlier that the mother palms of uniform standards have differential transmitting ability in regard to yield. In order to examine the variability in transmitting ability of different yield attributes the mean data of 10 families belonging to the three distinct yield groups of high (20 per cent above garden mean), medium and low (20 per cent below garden mean) were tabulated. The data are given in Table 1.

TABLE 1:

Variability in yield and yield attributes of 10 families

		High	Medium	Low
1.	No. of leaves shed	7.5	7.6	7.4
2.	No. of inflorescences produced	5.2	6.0	5.1
3.	No. of bunches harvested	3.1	3.1	2.8
4.	No. of female flowers per tree	1043.0	1172.0	1045.0
5.	Total number set	328.0	291.0	217.0
6.	Percentage of set	32.0	23.2	18.0
7.	No. of nuts harvested	271.7	222.6	159.0
8.	Total weight (kg)	9.7	8.7	6.1
9.	Mean weight per nut (g)	37.7	40.2	38.0
10.	No of nuts per bunch	78.3	65.2	50.5
11.	Percentage of bunches to inflorescences	57.6	49.0	51.5
12	Percentage of inflorescences to leaves shed	69.3	78.4	69.5
13.	Percentage of nuts harvested to nut set	78.6	73.2	71.5

From the above table it is seen that the differential behaviour of families in transmitting ability is due to the differential transmitting ability of percentage of set and the accompanying variability in the number of nuts and yield.

c) Heritability studies: Heritability of yield in arecanut being low (0.20), one method of improving mother palm selection is by selecting for characters correlated with yield and having high heritability. Age at first bearing had been found to be one such character; the results pertaining to it have already been reported in the last annual report. During the current year a further set of 10 characters were examined and the results obtained are presented in Table 2.

TABLE 2:

Heritability of yield components and their correlation with yield

			Correlation with yield		
		h^2	Pheno-typic	Geno-typic	Environmen-tal
1.	No. of leaves shed	0.32	0.19	0.53	0.35
2.	No. of inflorescences produced	0.46	0.41	0.02	0.59
3.	No. of bunches harvested	0.10	0.72	0.27	0.77
4.	No. of female flowers produced	0.08	0.55	0.44	0.65
5.	No. of nuts set	0.03	0.97	1.08	0.97
6.	Per cent of nut set	0.33	0.78	0.88	0.75
7.	Mean weight of nut	0.07	0.28	0.58	0.24
8.	No. of nuts per bunch	0.22	0.84	0.86	0.82
9.	% of bunches to inflore-scence	0.16	0.60	0.42	0.63
10.	% of inflorescences to leaves shed	0.60	0.42	0.04	0.69

It will be observed from Table 2 that out of the ten characters considered only percentage of inflorescences to leaves shed and number of inflorescences produced have moderately high heritability. However, since these two characters have a very low genotypic correlation with yield, they will not be useful as selection criteria for mother palm selection. The percentage set which has a high degree of correlation with yield and a heritability of 0 33 may be included as a criterion for selection of mother palms with advantage. It will also be seen that the genotypic correlation of 1.08 between number of nuts harvested indicate that nut shedding after setting is brought about purely by environmental condition. The heritability of percentage of nuts harvested to nuts set when worked out gave a value of 0.01 confirming the above conclusion. Thus the 20 per cent loss of yield due to nut shedding can be reduced by giving the optimum environmental conditions.

The data in Table 2 also show that the mean weight of nuts has negative phenotypic, genotypic and environmental correlations with number of nuts harvested. However, earlier studies have revealed absence of threshold value between these two characters indicating thereby that this negative correlation does not set a limit to the possible yield improvement.

b) RESEARCHES ON HAND

S. 1. Refinement of experimental technique

In collaboration with Regional Arecanut Research Station, Hirehalli, data are being gathered for working out a sampling technique for tendernut curing of the variety *Podi*.

S. 2. Correlation, heritability and causation studies

The work carried out so far on the above relates to only the Vittal type of arecanut grown under South Kanara conditions. To study the nature of variability of these results in relation to variety and location, data have been assembled from all the five Regional Stations for working out the correlation between different morphological characters of seedlings at the time of planting. The variability in yield attributes of palms of differential yielding ability is being studied.

S. 3. Discriminant function and selection index

Data collected from 300 progenies belonging to 10 mother palms in respect of 29 characters have been tabulated for setting up a selection index. Selection index will be worked out using all the 29 characters as well as groups of characters with a view to improve mother palm selection

(c) RESEARCHES CONTEMPLATED

It is proposed to work out heritability of some more yield attributes including the tissue analysis data. The possibility of exploiting hybrid vigour through the use of analysis of dispersion will be examined.

Programme of work for 1967

Number and name of the project	Venue of work
S. 1. Refinement of experimental technique	Vittal
S. 2 Correlation, heritability and causation studies	
a) Correlation between growth characters of seedlings	Vittal
b) Correlation between growth and other characters of the palm with yield	Vittal, Peechi and Hirehalli
c) Heritability studies	Vittal
S. 3. Discriminant function and selection index	Vittal

SOIL CHEMISTRY

(Dr. A. R. Kalbande)

SUMMARY OF SALIENT FINDINGS

Studies on movement and availability of surface-applied super phosphate indicated that the movement of PO_4 ions to lower soil depths was very much limited and that the increase in available phosphorus in subsurface layers was associated with the increasing dose of super phosphate. The downward movement of phosphate up to a depth of 20 cm was found to take place by about 10th day of application of super phosphate at the rate of 200 kg P_2O_5 per ha. Of the two methods of application of super phosphate tried, mixing with soil was found to limit the downward movement of PO_4 ions. Application of different types of green leaves and cattle manure showed an increase in organic carbon content in situ *over control after one month of application. Amongst the different types of green leaves and cattle manure studied forest leaf application recorded the maximum increase of 0.37 per cent organic carbon in the soil three months after application while a decrease in organic carbon content was recorded by* Gliricidia. *Significant decrease in the organic carbon content of the soil was seen in all the treatments of the N P K experiment at the end of five years of leaf* (Gliricidia) *application to areca palm. In a field experiment laid out at Palode, the treatment, planting on the terrace with permanent cover cropping + manuring maintained high soil organic carbon and available nitrogen status.*

(b) RESEARCHES ON HAND

C. 2. Mobility and availability of applied phosphorus in a soil profile.

An experiment to study the mobility and availability of PO_4 ions in the soil profile when applied to the soil surface at 0, 50, 100 and 200 kg P_2O_5 per ha was laid out on a randomised block design. Soil samples from 0–5, 5–10, 10–15, 15–20, and 20–30 cm depths were collected periodically and available P_2O_5 and moisture percentage determined immediately after collection. From the data collected it is seen that in the surface 5 cm soil layer the level of available P_2O_5 after 24 hours of application is increased by 0, 23, 31 and 48 folds over the initial level of 5 ppm for doses of 0, 50, 100 and 200 kg P_2O_5 per ha respectively. Maximum downward movement up to 20

cm depth was seen after 10 days of application at 200 kg $P_2 O_5$ per ha. The increase in available $P_2 O_5$ at 20 cm depth was about 8 times that of control (2.42 ppm) at the same level of application. At other two levels of super phosphate application, the movement of $P O_4$ ion was observed to be up to 10–15 cm depth after 10 days of application. However, the increase in available $P_2 O_5$ in sub-surface layers was found to be associated with the increase in dose of super phosphate. Thus the method and level of application of phosphorus play an important role.

Results obtained from the above experiment when compared with those from a similar experiment where super phosphate was applied thoroughly mixed with surface 10 cm soil depth showed that mixing of the fertilizer with the soil reduced the availability and movement of phosphorus to a great extent. It was seen that the available phosphorus status of surface 10 cm layer after 5 days of application was increased by 2, 6 and 10 folds over initial (5 ppm) when applied at the rate of 50, 100 and 200 kg per ha. Downward movement of $P O_4$ ion was found to be negligible.

The samples collected from the above experiment at different intervals have been air-dried to study the effect of sample drying on phosphorus availability.

C. 3. Comparative study of different green manure crops and their organic matter addition capacity

For a perennial crop like arecanut, maintenance of a high organic matter status in the soil all the year round is an important factor in production. Field observations had shown that green leaf from some of the green manure plants like *Gliricidia* does not leave much humus after a few days of its application. A field experiment on a randomised block design was, therefore, laid out to study the efficacy of different types of green leaves in adding organic matter to the soil. The leaves from forest trees, *Calopogonium, Pueraria, Mimosa, Stylosanthes* and *Gliricidia* were used. One plot applied with cattle manure (local practice) and another receiving no organic matter at all formed the controls. After one month of application of the organic sources soil samples were collected and organic carbon content determined. From the values obtained it was seen that all the types of green leaves and cattle manure increased the organic carbon content of the soil over control. Three months after application, the maximum increase of organic carbon (0.37 per cent) was seen in the plot applied with forest leaf, while there was a decrease of 0.09 per cent in the plot applied with *Gliricidia*. Further investigations are under way.

Miscellaneous

a) N P K manurial trial

From the N P K manurial trial laid out at the Central Station, soil samples are being regularly collected and analysed to study the plant nutrient status of the soil in different treatments. The data obtained for percentage organic carbon content were statistically analysed. The results are given in Table 2.

TABLE 2:

Organic carbon content of soil at different depths

Year of sampling	Depth of soil sampling in cm								
	0-15	15-45	45-90	0-15	15-45	45-90	0-15	15-45	45-90
	0 kg leaves/ 500 palms			3400 kg leaves/ 500 palms			6800 kg leaves/ 500 palms		
1962 (Initial)	0.80	0.62	0.41	0.87	0.67	0.47	0.86	0.74	0.46
1966	0.59	0.52	0.48	0.55	0.52	0.44	0.64	0.60	0.39

S E per plot — 0.20 S. E. per treatment mean — 0.04
Overall mean — 0.63 C. D. (P=0.05) — 0.11
C. V. (%) — 31.74

From the above it is seen that there is a significant decrease in the organic carbon content of the soil in all the treatments at the end of five years of leaf *(Gliricidia)* application. Since *(Gliricidia)* leaf has shown such a decrease in the organic matter content in another experiment reported elsewhere the source of leaf for this experiment was changed over to forest leaves from 1967 onwards.

b) Soil fertility studies under different methods of raising arecanut on hill slopes

An experiment laid out at Regional Research Station, Palode to study the effect of different methods of raising arecanut gardens on hill slopes on the incidence of yellow leaf disease was made use of for this study. The main treatments consisted of (1) planting on slope, (2) terracing at the site of planting and (3) planting on the terrace. The three subtreatments were (a) no cultivation+no manuring, (b) clean cultivation + manuring and (c) permanent cover cropping + manuring. The results of analysis showed that the status of organic carbon, available nitrogen and available $P_2 O_5$ is high in the permanent cover cropping + manuring treatment.

(c) RESEARCHES CONTEMPLATED

Studies on the release of N from different organic manures under the soil conditions existing in arecanut garden are proposed to be taken up for adjusting the inorganic fertilizer application to the crop. A permanent manurial experiment to study the effect of continued use of different manures has been programmed. Detailed soil survey of all the Research Stations will be made and soil maps prepared.

Programme of work for 1968

Number and name of the project	Venue of work
C. 1. Release of nitrogen to arecanut from different organic manures	Vittal
C. 2. Mobility and availability of applied phosphorus in soil profile	Vittal
C. 3. Comparative study of different green manure and cover crops and their organic matter addition capacity	Vittal, Mohitnagar, Peechi, Hirehalli and Kahikuchi
C. 4. Standardisation of sampling technique for plant sample	Vittal
C. 5. Studies on nutrient exhaustion by arecanut palm	Vittal
C. 6. Studies on composition changes in soil and plant by continuous use of fertilizers, manures and cultural practices	Vittal
C. 7. Soil survery of experimental farms	Vittal, Palode, Peechi, Hirehalli, Mohitnagar and Kahikuchi

PLANT PHYSIOLOGY

SUMMARY OF SALIENT FINDINGS

The field survey envisaged in the programme was completed during the period. The results showed that the soil under which arecanut was cultivated in these areas was shallow and subject to erosion to varied extent, that manuring was highly inadequate for main crop as well as for associate crops, that general crop management was poor and that the crop was attacked by a few major pests. Field experiments were laid out as per schedule of treatments and data gathered and scrutinised. Since the experiments are in the initial stages, no conclusions are possible from the data gathered. Soil samples collected prior to the commencement of the application of treatments were analysed for various elements.

(a) RESEARCHES COMPLETED

PP. 1. Scheme on comprehensive package plan trials on yellow leaf disease of arecanut

a) Field survey of the package plan unit areas:

The yellow leaf disease of arecanut which seems to have made its appearance around the year 1940 has affected 5 per cent of the plantations in the States of Kerala and Mysore. The affected palms lose vigour, their foliage turns yellow, nuts in different stages of development shed and the kernel becomes unfit for chewing. In due course the plants succumb to the malady. It is not uncommon to see gardens which have been wiped outdue to the disease. In order to study the symptomatology, nature of spread and factors associated with the disease a detailed survey covering a total of 200 arecanut gardens selected at random was taken up in the four disease-affected tracts of Jayapura (Mysore) and Annamanada, Koothattukulam and Punalur (Kerala). A standard questionnaire was used for the survey. The survey gave the following results:

In 85 per cent of the disease-affected gardens the soil is lateritic in nature, the remaining being black in colour. The textural study of the soil showed that in 80 per cent of the cases it is sandy to sandy loam. The depth of the soil in these areas is shallow, 74 per cent of the gardens having less than 50 cm depth of soil. The topography of the gardens in 50 per cent of the cases is fairly level. In the remaining cases it ranged from slight to steep slope. Study of the extent to which the gardens are subjected to flooding showd that only in one of the tracts (Annamanada) 82 per cent of

the gardens are submerged during monsoon whereas in the other tracts it is negligible. The drainage provided in the gardens is adequate only in 37 per cent of the cases while in the remaining it is inadequate. In 40 per cent of the gardens there is no soil erosion while in the rest the intensity varies widely.

The plants in 90 per cent of the gardens are spaced irregularly with mixed and intercrops such as coconut, pepper, banana, tapioca, etc. Both arecanut as well as the intercrops are not receiving any manurial treatment in about 28 per cent of the cases while 45 per cent of the gardens are manured with organics alone and the remaining with inorganics or combination of inorganic and organic. Of the disease-affected gardens 50 per cent of the area is irrigated, the rest being purely rainfed. The gardens are generally intercultivated in 88 per cent of the cases, the common practice of weeding alone accounting to about 40 per cent.

About 62 per cent of the disease-affected palms are in the age group of 5 to 25 years and about 25 per cent in the prebearing age. The oldest leaf was invariably found to be the first to turn yellow. Yellowing then gradually spreads upwards. In about 80 per cent of the gardens the appearance of the disease was sporadic in nature. The leaf size of the affected palms is reduced in about 60 per cent of the gardens with 70 per cent showing yellowing of more than three leaves. In about half the gardens, symptoms like yellowing, necrosis and fall of tissues were confined to tip of the leaves while in about 37 per cent severe yellowing was noticed. Forty three per cent of the gardens have kernel discolouration and 60 per cent abnormal tender nut fall.

Of the pests and diseases, spindle bug is found to be quite serious and 38 per cent of the gardens are found to be attacked by this pest. In all the three tracts of Kerala it was also observed that inter and associate crops such as coconut, banana and tapioca have been affected by root (wilt) disease, bunchy top and the tapioca mosaic virus respectively.

(b) RESEARCHES ON HAND

PP. 1. Scheme on comprehensive package plan trials on yellow leaf disease of arecanut.

b) Field layouts:

Field experiments involving the application of macro nutrients (N, P, K, Ca) and micro nutrients (Fe, B, Zn, Mg, Mn) laid out during the year 1965 and 1966 on a 13 X 26 randomised block design were continued. A method of evaluating the different characters based on scores was standardised for making the treatment comparisons efficient. The

analysis of the data pertaining to the symptomatology collected during the year, in respect of the 3 replications at Punalur which had received the manurial treatments during 1965 and 1966 did not show any significant effect of the treatments. The yield data also showed a similar trend. Data relating to the remaining 23 replications in which the treatments were imposed during the year 1966 were also examined. Since the response for such applications in a crop like arecanut can only be observed after longer periods than what has now been given, the response of treatments can be expected only in due course.

c) Chemical analysis of soil, plant tissues and nuts:

Analysis of soil samples collected from the experimental plots prior to the commencement of the treatment application was continued. It was seen that the soils from all the units are acidic with pH values ranging from 4.2 to 5.4. Organic carbon content was medium to high. Wide variation of 124 to 441 ppm was seen in the case of available nitrogen content. Available phosphorus content of the soil was very low to medium. In the soils from Punalur unit the percentage content of P_2O_5, CaO and MgO was 0.29, 0.051 and 0.31 respectively.

(c) RESEARCHES CONTEMPLATED

Since the Research Officer had not joined the post during the period under report the work pertaining to pot culture studies could not be taken up. The same will be initiated.

Programme of work for 1968

Number and name of the project	Venue of work
PP. 1. Investigation on yellow leaf disease of arecanut a) Survey for assessing the area affected by yellow leaf disease b) Field experiments (with macro & micro nutrients) in growers' fields c) Chemical analysis of soil and plant tissues and nuts	Vittal, Koothattukulam, Annamanada, Jayapura, Punalur and Palode

ENTOMOLOGY

SUMMARY OF SALIENT FINDINGS

Laboratory trials conducted with different acaricides against white mite have shown that Kelthane at 186 ml per 100 litres of water has the maximum ovicidal efficacy. Work on biological control of mites initiated in collaboration with Commonwealth Institute of Biological Control was continued. Studies on the life history and intensity of incidence of white grub, spindle bug and inflorescence caterpillar were in progress.

(a) RESEARCHES COMPLETED

E. 1. Control of mites

Field trials conducted in the earlier years at the Central Station had shown that Kelthane and Trithion were effective in checking the reinfestation of colonies. Laboratory tests were conducted during the year to assess the ovicidal efficacy of the different acaricides such as (1) Akar-338 (1 ml), (2) Kelthane (0.93 ml), (3) Kelthane (1.86 ml), (4) Trithion (1.26 ml) and (5) Mitex (2 ml) per litre of water against white mite *(Paratetranychus indicus)*. The control consisted of spraying with water alone The results of laboratory experiments done on a randomised block design in respect of white mite are given in Table 1

TABLE 1:

Mean progressive hatching of eggs of white mite *(Paratetranychus indicus)*

Treatments	Obeservations made after			
	24 hrs.	48 hrs.	72 hrs.	96 hrs.
1. Akar-338	5.38	15.42	28.73	36.67
2. Kelthane (0.93 ml/litre)	10.42	15.00	27.03	39.16
3. Kelthane (1.86 ml/litre)	2.07	7.53	12.23	13.91
4. Trithion	5.01	12.07	24.17	32.08
5. Mitex	4.99	14.16	28.14	32.91
6. Control	20.83	39.60	61.67	77.90
S. E. per treatment mean	2.08	2.92	3.99	4.12
C. D. (P=0.05)	4.42	6.18	8.46	8.74

From the above it can be seen that Kelthane at 1.86 ml per litre of water has the maximum ovicidal effect which is significantly better than the rest of the treatments. A similar trial against red mite taken up during the previous year had shown that Kelthane, Trithion and Akar-338 were equally effective.

(b) RESEARCHES ON HAND

E. 1. Control of mites

Biological control of mites which was initiated in previous year was continued. A nucleus culture of *Phytoseiulus persimilis*, a predacious mite was brought from Commonwealth Institute of Biological Control, for multiplication and acclamatisation in this tract. The work is being continued.

E. 2. Studies on the control of inflorescence caterpillar.

The inflorescence caterpillar *(Tirathaba mandella)* which had been observed to attack the inflorescences under South Kanara conditions was found to attack nuts as well in different stages of maturity at Palode and Kahikuchi. A comprehensive programme of work is being drawn up.

E. 3. Studies on the biology and control of white grub

The grubs of cockchafer beetle feed on the tender roots of arecanut and cause considerable reduction in the yield and vigour of palms. In severe cases of infestation the trees will succumb to the attack. Of late, the pest has gained serious proportions. The life history and biology of the pest were being studied during the period under report by rearing the grubs on roots of arecanut seedlings planted in pots. As the mortality was very high only one adult beetle emerged. This was identified as *Xylotopeus gideon* by the Commonwealth Institute of Entomology, London. The studies are being continued.

E. 5. Bionomics and control of spindle bug

Counting of spindle bug population on 50 palms was commenced at Peechi for finding the seasonal variation in the intensity of incidence of the pest. Wide variability in population count was observed to exist in different months.

E. 6. Survey for assessing crop losses due to pests

The methodology adopted in other crops for similar studies was reviewed.

(c) RESEARCHES CONTEMPLATED

Methods of control of red ants and scales and study of symbiotic relationship between these are to be taken up. The insect which causes severe tender nut fall is to be trapped and identified.

Programme of work for 1968

Number and name of the project	Venue of work
E. 1. Biological control of mites	Vittal
E. 2. Studies on the control of the inflorescence caterpillar *(Tirathaba mundella)*	Vittal
E. 3. Studies on the biology and control of white grub *(Leucopholis bermeisteri)*	Vittal and Hirehalli
E. 4. Studies on the stem borer pest *(Xyleborus perforans)* of arecanut palms and mode of control	Vittal
E. 5. Bionomics and control of spindle bug	Palode, Peechi and Vittal
E. 6. Survey for assessing crop losses due to pest a) Mites (b) Spindle bug c) Inflorescence caterpillar d) Root-grub	Vittal, Palode, Peechi, Hirehalli and Mohitnagar

PATHOLOGY

(T. S. S. Rawther)

SUMMARY OF SALIENT FINDINGS

Studies with different copper fungicides using low volume spray for the control of Koleroga *disease showed that none of the proprietary fungicides gives as much copper deposit and consequent protection to nuts as Bordeaux mixture. In the yellow leaf disease, foliar yellowing was found to be not related to endosperm discolouration. Transmission of yellow leaf disease by different methods failed to give any symptoms in the hosts used. There was no incidence of yellow leaf disease at the Palode Research Station in any of the agronomic or botanical trials laid out in connection with this disease. Investigations on crown rot, a new disease from Assam, showed that the disease is caused by* Thielaviopsis *sp.*

(a) RESEARCHES COMPLETED

P. 1. Investigation on *Koleroga (Phytophthora arecae)*

(a) Trial on the control of Koleroga *using low volume spray and (b) studies on the retention of copper compounds sprayed on fruits in field:*

Koleroga or *Mahali* or fruit rot caused by the fungus *Phytophthora arecae* is one of the most important diseases of arecanut palm and accounts for enormous crop losses in most of the arecanut growing areas. Though adequate control can be achieved by spraying one per cent Bordeaux mixture, preparation and spraying of the same during the monsoon months are confronted with various problems especially due to the tall nature of the palms. To explore the possibility of using low volume sprayers and also the efficacy of proprietary copper oxychlorides as against Bordeaux mixture, large scale trials were in progress since 1960-61 at the Central Station as well as in private gardens. In the initial trials Fycol 8 and Lovol were sprayed using Micron 420. Satisfactory control could not be achieved.

The trials were repeated during the year, using the Mini-micron SK 77 sprayer (shoulder model) with Fycol 8E (2.5 litres in 30 litres of water and 2.5 litres in 17.5 litres of sovaspray oil), Oleocop and Fycol 8 (each 2.5 litres in 17.5 litres of sovaspray oil). The control which consisted of Bordeaux mixture was sprayed using ordinary high volume rocker sprayer. The trial was conducted in two replications with an approximate plot size of half acre

for each treatment. While the percentage of trees infected ranged from 21 to 68 in plots sprayed with low volume sprayer only 8 per cent infection was noticed in Bordeaux mixture-sprayed plots.

Samples of nuts collected one day and 40 days after spraying from the different treatments were analysed for copper deposit and the results are given in Table 1.

TABLE 1:

Copper deposit on nuts sprayed with different fungicides

Sl. No.	Fungicide	Type of sprayer	Percentage infection	Copper deposit in micrograms per ml of nut (mean value)	
				1 day after spraying	40 days after spraying
1.	Fycol 8E in water	Low volume	68	7.34	5.59
2.	Fycol 8E in oil	— do —	21	5.28	4.80
3.	Oleocop in oil	— do —	29	7.48	4.11
4.	Fycol 8 in oil	— do —	28	7.36	4.35
5.	Bordeaux mixture	High volume	8	15.52	7.63

It is seen that none of the proprietary fungicides tried using the low volume sprayer gives as much copper deposit and consequent protection against fungal infection as Bordeaux mixture.

The results indicate the necessity for evolving a more sophisticated low volume sprayer for spraying areca.

(b) RESEARCHES ON HAND

P. 4. Investigations on yellow leaf disease of arecanut in Kerala

a) Pathological aspects

i) Symptomatology:

Symptomatology studies which were commenced earlier were continued. Detailed study of root system showed that a higher percentage of rotting of main roots and branch roots exists in palms in advanced stage of disease as compared to healthy ones and in palms at initial stage of infection. Foliar yellowing and endosperm discolouration were not found to be inter-dependent.

ii) Studies on virus association:

Inoculation studies by sap, insect and other agents done so far have failed to transmit the disease. Monthly inoculation of sap from leaves of diseased arecanut on 125 healthy trees also failed to produce any symptom of yellow leaf disease on the inoculated palms.

iii) Studies on association of nematodes:

Dr. Weisher, F. A. O. Nematologist, who examined the soil samples collected from diseased and healthy gardens found the presence of five genera of nematodes in the soils. Neither the presence of nematodes nor their population density could be correlated with the disease. Further work on the possible role of nematodes as vectors of yellow leaf disease has to be taken up.

b) Botanical aspects

Twenty-five indigenous and exotic varieties planted in a replicated design during 1961-62 and 13 types planted in 1964-65 were maintained with a view to screening them for disease resistance. Since there was no disease incidence in the entire garden of the Research Station at Palode the work on this aspect could not be done.

c) Agronomic aspects

For a long time it is suspected that the disease is associated with the neglected cultivation practices adopted in Kerala. Trials involving application of macro- and micro-nutrients with and without irrigation, planting on hill slopes adopting both the cultivators' and improved practices and raising of arecanut mixed with other crops such as coconut laid out in the earlier years were maintained with a view to finding out the influence of these factors on disease incidence. Till to-date, no symptoms of the disease have appeared in any of the plots.

d) Physiological aspects

According to the suggestions of Dr. Holmes, F. A. O. Expert, who visited the yellow leaf disease areas, an observation trial to study the effect of administering Mn, Mg and Fe in the form of $MnSO_4$, $MgSO_4$ and $FeSO_4$ as nutrient solutions through the cut ends of leaf tips was taken up. The plants receiving Mg showed slight improvement as compared to control.

P. 6. Study of crown rot disease in Assam

Crown rot, a new disease, is causing serious damage to the crop in Assam. The diseased specimens collected from K. and J. Hills were examined for the presence of fungi, bacteria etc., employing various culture media.

Gram positive and negative bacteria as well as a fungus (*Thielaviopsis* sp.) were isolated. Back inoculation tests were conducted during the period to test the pathogenicity of the bacteria and *Thielaviopsis* sp. The latter alone gave successful infection. Investigations are being continued.

c) RESEARCHES CONTEMPLATED

Laboratory and field investigations for finding out the cause of *Band* disease and control for *Anabe* roga (caused by *Ganoderma lucidum*) are being initiated. Survey for assessing the incidence and losses due to diseases like *Koleroga* and *Anabe* in areca palms and fungal infection of the processed arecanuts have also been planned.

Programme of work for 1968

Number and name of the project	Venue of work
P. 1. Investigations on *Koleroga (Phytophthora arecae)* a) Trials on the control of *Koleroga* using low volume spray b) Studies on the retention of copper compounds sprayed on the fruits in the field c) Studies on the forecasting of the incidence of *Koleroga*	Vittal and Peechi
P. 2. Investigation on *Band* disease	Vittal, Mohitnagar and Hirehalli
P. 3. Investigations on *Anabe*	Vittal, Hirehalli and Kahikuchi
P. 4. Investigations on yellow leaf disease of arecanut in Kerala. Pathological, virus, physiological, entomological, agronomic and botanical aspects	Palode
P. 5. Survey for assessing crop losses due to diseases (a) *Koleroga* (b) *Anabe*	Peechi, Vittal, Hirehalli and Kahikuchi
P. 6. Study of the crown rot disease in Assam	Kahikuchi and Vittal
P. 7. Fungal and pest infection of processed arecanuts	Vittal, Peechi, Hirehalli, Palode, Kahikuchi and Mohitnagar

III. PAPERS PUBLISHED

During the period under report the following technical papers were written up and sent for publication:

1. Bavappa, K. V. A. and Ramachander, P. R. It's worthwhile selecting areca seedlings with care.

2. Bavappa, K. V. A. and Ramachander, P. R. Selection in arecanut palm.

3. Kumar, S. N. S., Naidu, G. V. B. and Sannamarappa, M. Investigations on the utilisation of arecanut husk in horticulture.

4. Murthy, K. N. Crown rot of arecanut.

5. Nair, R. B. and Rawther, T. S. S. Studies on arecanut pollen with reference to yellow leaf disease.

6. Nair, R. B. and Rawther, T. S. S. A note on some new pests of arecanut palm.

7. Rawther, T. S. S., Nair, R. B. and Velappan, E. Further studies on yellow leaf disease of arecanut.

8. Seshadri, S. N. *Spatulifimbria gresia* Herring as a new pest of arecanut.

9. Shama Bhat, K. and Leela, M. The effect of density of planting on the distribution of arecanut roots.

10. Velappan, E. and Rawther, T. S. S. Study of different methods of raising arecanut gardens on hill slopes.

IV. EXTENSION

a) Results of immediate practical application

(1) Under the South Kanara conditions it was seen that a spacing of 2.7 m X 2.7 m gives the maximum yield per hectare. It was also observed that the maximum net profit is obtained from palms under this spacing.

(2) Growing banana as an intercrop during the initial four years of the arecanut plantation was not found to have any adverse effect on the growth of arecanut palms.

(3) In Southern Kerala where arecanut gardens are not normally irrigated, it was found that manuring with irrigation gives three times as much yield as manuring alone during the initial years of bearing. The response of the crop to irrigation is thus evident.

(4) The source of bulky organic manure was found to have considerable effect on the organic matter content of the soil. Forest leaf and cattle manure were found to be the best sources while *Gliricidia* was found to decrease the organic matter status. The result is of considerable importance to perennial crops like arecanut which are manured only once in a year.

b) Results likely to be useful to farmers but needing further trials

(1) In the studies on floral initiation it is observed that one inflorescence is initiated in every leaf axil. However, every leaf fall is not accompanied by production of an inflorescence. It has been observed in certain agronomic trials that production of inflorescences is highly influenced by the agronomic practices which the palms are subjected to. Determination of optimum conditions under which maximum production of inflorescences can be obtained is being done.

(2) Of the many different types grown in the exotic collection plot, five introductions have given about three times more yield than that of the local. Large scale trials in the cultivators' fields are being organised for studying their field performance before they are released for cultivation.

(3) Assisted pollination trials conducted during the year indicated the possibility of getting 10 per cent increase in yield. It was seen that this increase in yield does not cover the additional expenditure involved. Studies in improving the technique as well as the possibility of selective pollination are being made.

(4) Deeper planting of seedlings was found to have a decided advantage over shallower plantings. Palms planted at 90 cm depth were found to

have the maximum percentage of inflorescences to leaves shed. The experiment is in progress.

(5) Preliminary studies have indicated the distinct possibility of growing cacao and arecanut as a mixed plantation. Large scale trials are being programmed to work out the optimum cultivation practices for such a mixed crop husbandry.

(6) A field survey of the yellow leaf disease tracts has shown that cultivation practices adopted for arecanut in these areas are very poor. Agronomic trials involving application of micro- and macro-nutrients, irrigation etc., are being undertaken in these tracts to study the response of diseased palms to these treatments.

c) Publicity activities

For making the arecanut cultivators acquainted with the activities of the Research Station Farmers' Week was organised at the Regional Arecanut Research Station, Kahikuchi. Shri L. P. Goswami, Minister of Agriculture, Assam State presided over the function. The Research Station also participated in several exhibitions and gave wide publicity to the findings.

The Central and Regional Stations also attracted large number of post-graduate and under-graduate students from Karnataka University, Dharwar, University of Agricultural Sciences, Bangalore, University of Gauhati, Agricultural Colleges, Bapatla, Jorhat etc. The studente were told about the work in progress. Besides, large number of trainees from different State Government Institutions and Departments also visited the Station for getting first-hand information on the crop. They were given intensive training on all aspects of arecanut cultivation. The Stations were also in touch with growers and trade interests throughout the country for identifying the problems in the field. A new problem on the fungal damage of processed nut was identified and work initiated. Large number of enquiries seeking advice on various aspects of the crop were attended to promptly. Growers from distant parts also visited the Stations and obtained guidance. The Arecanut Specialist and staff paid visits to the gardens for on-the-spot inspections.

V. CONFERENCES AND SYMPOSIA

The Station organised during the year the first conference of arecanut research workers, in which ten papers were presented. In addition the technical programmes of the Station were also discussed in detail.

VI. SUMMARY OF THE REPORT

The Central as well as Regional Stations continued the collection and testing of varieties from foreign countries and different parts of India. A total of seven species and types were introduced during the year. Of the different types that are being grown in the collection plot, five exotic introductions have given three times more yield than that of local. Studies on the floral initiation revealed the presence of potential inflorescences in every leaf axil including the leaf primordia. The inflorescences that get aborted were found to be those that should have commenced active growth during the months of February, March and April. Since production of inflorescences is highly influenced by agronomic factors, the optimum conditions of growth under which maximum number of inflorescences can be produced are being determined A large scale crossing programme involving five distinct types of arecanut and two species *(A. catechu* and *A. triandra)* for transfer of desirable characters and exploiting hybrid vigour was in progress. Hybrids produced earlier were transplanted to the main field. Floral biology studies of arecanut were repeated under the Assam conditions. The results confirmed the earlier finding that arecanut under normal conditions is cross pollinated. The selection programme for improvement of arecanut formulated earlier was improved by the addition of a polycross technique. Assisted pollination using sucrose plus agar medium was found to increase the percentage of set by 10 per cent. Sixteen per cent increase in set was obtained at Kahikuchi by spraying Bordeaux mixture plus Endrex in two rounds.

Planting seedlings up to two years in age, whether directly or after transplanting in the nursery does not affect their initial flowering. The widest spacing of 3.6 m X 3.6 m adopted in the spacing experiment gave the maximum sun-scorch of 54 per cent. The maximum number and weight of fruits harvested per unit area were found to centre round spacings of 2.7 m X 2.7 m and 3.6 m X 1.8 m at Vittal and Peechi respectively. Irrigation at closer intervals was found to considerably increase the number of palms coming to flower early as well as the number of inflorescences per palm. In the rainfed tract of South Kerala irrigation was found to give considerably enhanced yields over plots not receiving irrigation In the trial at Peechi, deeper planting was found to be advantageous. The growth of arecanut plants was not found to be affected by raising the intercrop of banana during the initial four years. The intercrop trial at Peechi has been relaid with pepper and ginger as intercrops. In the mixed cropping trial with cacao and arecanut, cacao was found to give high yield. The growth of arecanut was not affected. The palms grown under clean cultivation and

manuring in the rainfed tract of Kerala were found to be more vigorous than those grown under permanent cover cropping and manuring as well as no cultivation and no manuring.

Palms receiving 25 Kg nitrogen per 500 palms were found to give significantly more yield than those receiving no nitrogen. Application of green leaf at 6800 Kg per 500 palms gave higher yields than plots receiving no green leaf. The palms were found to respond to higher doses of potash in a trial laid out at Peechi. The application of N. P. K. in either organic or inorganic form was not found to affect the yield. Trials to find out the optimum intercultivation requirements of the crop were laid out at Hirehalli and Peechi.

The sampling technique for determination of the percentage of *Choor*, a trade variety of processed tender nut, was worked out. Among the yield components, percentage of fruit-set was found to be the most important. This character was also found to be a better selection standard than yield. The entire 20 per cent shedding which takes place after the nuts are set was found to be not controlled genetically. Sufficient scope, therefore, exists to reduce this shedding by working out the optimum environmental requirement of the crop. The reduction in size of fruits with increase in number of nuts was not found to reduce the total yield.

It was found that the source of P has to be modified because of the rapid non-availability of the nutrient when it is applied in the form of super phosphate on the soil surface. Farm yard manure and forest leaf were found to be the best sources for supply of organic matter to the soil.

A survey of the yellow leaf disease-affected gardens of Kerala and Mysore showed that the soil under which this disease occurs is shallow and subject to erosion. The standard of crop management and manuring is very poor. It was also found that the yellowing of leaves and blackening of kernel were almost independent of each other. Sap inoculation studies failed to transmit the disease.

The use of low volume sprayers for spraying against *Koleroga* (fruit-rot caused by *Phytophthora arecae*) was found to be not satisfactory. Kelthane at 186 ml per 100 litres of water was found to be the best for control of mites, a major pest of arecanut. Studies on the life history of other major pests like white grub, spindle bug etc., are in progress with a view to making the control of these pests much more effective.

VII. PERSONNEL

Retirements, promotions and transfers

Shri R. K. Bhattacharya, Research Assistant (Agronomy), Regional Arecanut Research Station, Kahikuchi was appointed as Research Officer and transferred to Regional Arecanut Research Station, Mohitnagar with effect from 3.5.1967. Sarvashree C. S. Abraham, Research Assistant (Pathology), Regional Arecanut Research Station, Peechi and M. Sannamarappa, Research Assistant (Agronomy), Regional Arecanut Research Station, Hirehalli were appointed as Research Officers on *ad hoc* basis in the respective Research Stations with effect from 6.11.1967. Shri M. Vijayarajan, Farm Assistant, Regional Arecanut Research Station, Peechi was appointed as Research Officer and posted against the leave vacancy of Shri T. S. S. Rawther, Research Officer, Regional Arecanut Research Station, Palode with effect from 11.12.1967 to 20.1.1968. Sarvashree N. Tirumaleshwar Bhat, Senior Research Assistant (Chemistry), Central Arecanut Research Station, Vittal, R. Balakrishnan Nair, Senior Research Assistant (Botany) and E. Velappan, Research Assistant (Agronomy), Regional Arecanut Research Station, Palode proceeded on study leave for prosecuting M.Sc. (Ag.)course. Shri N. Tirumaleshwar Bhat was granted a Junior Fellowship of the Indian Council of Agricultural Research. Shri R. Soman Nair, Fieldman, Regional Arecanut Research Station, Palode was sent for training in Agricultural Meteorology from 8.12.1967 onwards for a period of 30 days at the Directorate of Agricultural Meteorology, Poona.

Sarvashree P. R. V. Subramania Iyer, Senior Research Assistant (Agronomy), R. Sankaranarayana Pillai, Senior Research Assistant (Botany), P. Prasanna Kumar, Senior Research Assistant (Pathology), K. Annaji Rao, Research Assistant (Botany), A. Manjunatha Shetty, Farm Assistant and S. Jayasheela Hegde, Nursery Assistant joined duty at Central Arecanut Research Station, Vittal, while P. Pankajakshan Nair, Farm Assistant, Gorachand Biswas, Research Assistant (Agronomy) and Ram Keshwar Singh, Farm Assistant joined their respective posts at the Regional Arecanut Research Stations at Palode and Mohitnagar.

Staff: Section-wise

Central Arecanut Research Station, Vittal

Arecanut Specialist	Shri K. V. Ahamed Bavappa, M.Sc (Ag)
Botany	
Botanist	Vacant

Senior Research Assistant	Shri R. Sankaranarayana Pillai, M.Sc. (Ag.)
Research Assistant	Shri K. Annaji Rao, B.Sc.
Agronomy	
Agronomist	Shri K. Shama Bhat, M.Sc.(Ag.)
Senior Research Assistant	Kumari M. Leela, B Sc.(Ag.)
— do —	Shri P. R. V. Subramania Iyer, M.Sc.(Ag.)
Research Assistant	Shri K. B. Abdul Khader, B.Sc.(Ag.)
— do —	Vacant
Farm	
Farm Superintendent	Shri K. J. Abraham, B.Sc.(Ag.)
Farm Assistant	Shri A. Manjunatha Shetty, B.Sc.(Ag.)
Nursery Assistant	Shri S. Jayasheela Hegde, B.Sc.(Ag.)
Statistics	
Statistical Officer	Shri P. R. Ramachandra, M.A., Diploma in Statistics (I. C. A. R.)
Computor	Shri K. Vijaya Kumar, B.Sc.
Soil Chemistry	
Soil Chemist	Dr. A. R. Kalbande, Ph. D., Assoc. I. A. R. I.
Senior Research Assistant	Shri N. Tirumaleshwar Bhat, B.Sc.(Ag.)
Plant Pathology	
Plant Pathologist	Vacant
Senior Research Assistant	Shri Prasanna Kumar, M.Sc.(Ag.)
Entomology	
Entomologist	Vacant
Research Assistant	Shri S. N. Seshadri, B.Sc.(Ag.)
Plant Physiology	
Research Officer (Plant Physiology)	Vacant
Research Assistant (Agronomy)	Shri B. Nagaraj, B.Sc.(Ag.)
— do —	Shri C. K. Mathai, B.Sc.(Ag.)
— do —	Shri K. Vellaichamy, B.Sc.(Ag.)
Research Assistant (Chemistry)	Shri C. Devaraju B.Sc.(Ag.)
Administration:	
Administrative Officer	Shri R. N. Juneja, M. A., LL B.
Assistant Administrative Offieer	Shri N. K. Srinivasa Murthy, B.Com.
Accounts Officer	Shri V.N.Dambal, B.A.(Hons.), S.R.A.S.

Regional Arecanut Research Station, Peechi

Research Officer	Shri C. S. Abraham, M.Sc.(Ag.)
Research Assistant (Pathology)	Vacant
Research Assistant (Agronomy)	Shri K. J. Antony, M.Sc.(Ag.)
Farm Assistant	Shri M. Vijayarajan, B.Sc.(Ag.)

Regional Arecanut Research Station, Palode

Research Officer	Shri T. S. S. Rawther, M.Sc.
Senior Research Assistant (Botany)	Shri R. Balakrishnan Nair, B.Sc.
Research Assistant (Agronomy)	Shri E. Velappan, B.Sc.(Ag.)
Farm Assistant	Shri P. Pankajakshan Nair, B.Sc.(Ag.)

Regional Arecanut Research Station, Hirehalli

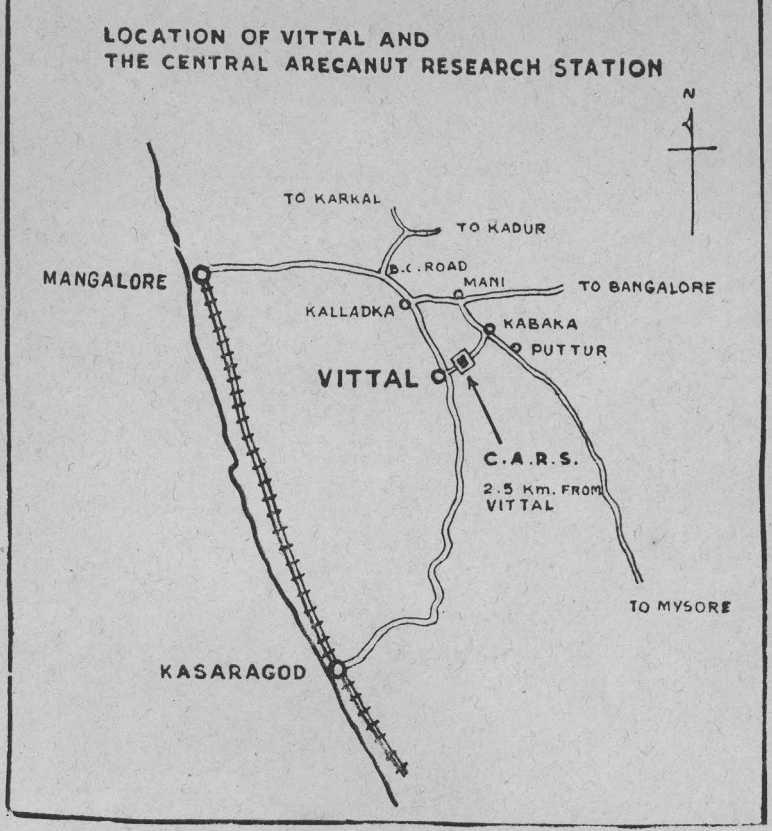
Research Officer	Shri M. Sannamarappa, B.Sc (Ag.)
Research Assistant (Agronomy)	Vacant
Research Assistant (Pathology)	Shri S. N. Sampath Kumar, B.Sc.(Ag.)
Farm Assistant	Vacant

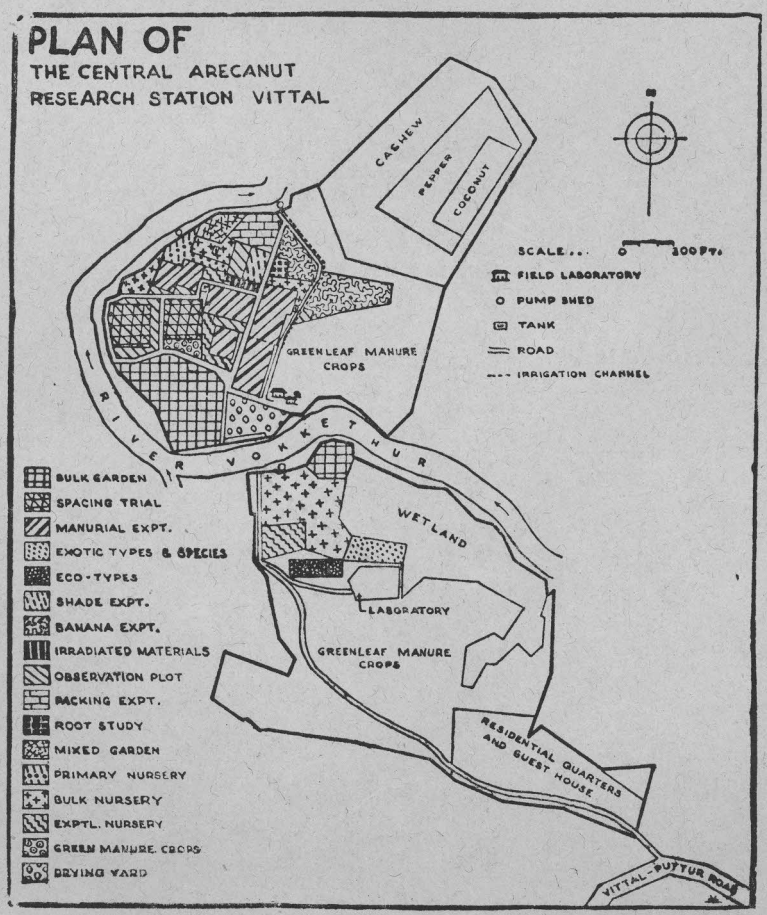
Regional Arecanut Research Station, Mohitnagar

Research Officer	Shri R. K. Bhattacharya, B.Sc.(Ag.)
Research Assistant (Pathology)	Vacant
Research Assistant (Agronomy)	Gorachand Biswas, M.Sc.(Ag.)
Farm Assistant	Shri Ram Keshwar Singh, B.Sc.(Ag.)

Regional Arecanut Research Station, Kahikuchi

Research Officer	Shri K. Narasimha Murthy, M.Sc.(Agri.)
Research Assistant (Agronomy)	Vacant
Research Assistant (Pathology)	Vacant
Farm Assistant	Vacant


LOCATION OF VITTAL AND
THE CENTRAL ARECANUT RESEARCH STATION
N
TO KARKAL
TO KADUR
B.C. ROAD
MANI
TO BANGALORE
MANGALORE
KALLADKA
KABAKA
PUTTUR
VITTAL
C.A.R.S.
2.5 Km. FROM VITTAL
TO MYSORE
KASARAGOD


PLAN OF
THE CENTRAL ARECANUT
RESEARCH STATION VITTAL
CASHEW
PEPPER
COCONUT
SCALE... 0 100 Ft.
FIELD LABORATORY
PUMP SHED
TANK
ROAD
IRRIGATION CHANNEL
GREENLEAF MANURE CROPS
RIVER VOKKETHUR
WETLAND
LABORATORY
GREENLEAF MANURE CROPS
RESIDENTIAL QUARTERS AND GUEST HOUSE
VITTAL-PUTTUR ROAD
BULK GARDEN
SPACING TRIAL
MANURIAL EXPT.
EXOTIC TYPES & SPECIES
ECO-TYPES
SHADE EXPT.
BANANA EXPT.
IRRADIATED MATERIALS
OBSERVATION PLOT
PACKING EXPT.
ROOT STUDY
MIXED GARDEN
PRIMARY NURSERY
BULK NURSERY
EXPTL. NURSERY
GREEN MANURE CROPS
DRYING YARD