ANNUAL REPORT

1973

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

KASARAGOD 670 124

KERALA STATE, INDIA

1974

CONTENTS

	Page
DIRECTOR'S INTRODUCTION	1
PROGRESS OF RESEARCH	10
COCONUT	
Genetics	11
Agronomy	19
Soil Chemistry	40
Plant Physiology	45
Biochemistry	49
Technology	50
Microbiology	51
Plant Pathology	54
Nematology	62
Entomology	63
Extension	75
ARECANUT	
Genetics	79
Agronomy	85
Soil Chemistry	98
Biochemistry	107
Technology	108
Plant Physiology	110
Plant Pathology	117
Entomology	121
Summary of work done at the co-ordinating centres, All India Co-ordinated Coconut and Arecanut Improvement Project	126

CASHEW

Genetics 129

Agronomy 132

Plant Pathology 134

Entomology 137

SPICES

Genetics 141

Agronomy 144

Biochemistry 146

Plant Pathology 149

Entomology 152

Summary of work done at the co-ordinating centres, All India Co-ordinated Spices and Cashewnut Improvement Project 157

SUMMARY OF THE REPORT 159

PUBLICATIONS 164

EXTENSION 167

CONFERENCES AND SYMPOSIA 170

PERSONNEL 173

DIRECTOR'S INTRODUCTION

HISTORY

This is the fourth annual report of the Central Plantation Crops Research Institute. This Institute was established in 1970 by merging together the two Central Coconut Research Stations at Kasaragod and Kayangulam (both in Kerala), and also the Central Arecanut Research Station at Vittal (Karnataka) and its substations at Peechi (Kerala), Palode (Kerala), Hirehalli (Karnataka), Mohitnagar (West Bengal), and Kahikuchi (Assam). With its headquarters at Kasaragod (Kerala), it now has two regional stations, six substations, and two seed farms. (A sixth substation was established at Sipighat, Andamans in 1971 and two seed farms are being organized at Kidu, near Subramanya, and at Shantigodu, near Puttur, both in South Kanara district, Karnataka). The regional and substations are located in different agroclimatic zones where plantation crops are grown.

The headquarters of the Institute is in Kudlu village, Kasaragod taluk, Cannanore district, Kerala State. The Institute farm has an area of 74.4 ha. The soil varies from littoral sand to laterite and the pH ranges from 5.9 - 6.5. It is only 10.7 m above MSL. The Institute is located five km north of Kasaragod Railway Station and 26 km south of Mangalore on the Bombay-Kanyakumari National Highway.

The Regional Station, Vittal, is in Buntwal taluk of South Kanara district. Karnataka State. It is 45 km south-east of Mangalore and is about 200 m above MSL. The area of the farm is 57.7 ha. Most of the soil is typical laterite admixed with sand, alluvial deposits, and gravel. It is acidic with a pH of about 5.3.

The Regional Station, Kayangulam, is in Kayamkulam Municipality of Alleppey district, Kerala State. It is five km south of Kayangulam Railway Station. It is only about three m above MSL. The farm is 27.3 ha in area The soil varies from sand to loamy sand with pH ranging from 5.0 - 6.0.

The Substation, Peechi, is in Trichur district of Kerala State. It is 19 km east of Trichur Railway Station. It is 49.6 m above MSL. The area of the farm is 14.2 ha. The upper layer of the soil is alluvial with a good admixture of sand and silt and the lower layer lateritic. The pH of the soil varies from 5.6 - 6.8.

The Substation, Palode, is in Nedumangad village of Trivandrum district, Kerala State. It is 36 km away from Trivandrum city. Its elevation is 210-240 m above MSL. The farm is 11.8 ha in extent, and the soil is mainly lateritic with pH ranging from 4.2 - 5.0.

The Substation, Hirehalli, is near the Hirehalli Railway Station, in Tumkur district of Karnataka State. It is 58 km away from Bangalore on the Bangalore-Tumkur Highway. Its elevation is 845 m above MSL. The farm is 16.2 ha in area. The soil is clay to clay loam with a pH of about 6.2.

The Substation, Mohitnagar, is in Jalpaiguri district, West Bengal. It is located 10 km north-west of Jalpaiguri. Its farm is 10 ha in extent. The soil is alluvium with pH ranging from 4.5 - 6.0.

The Substation, Kahikuchi, is near the Gauhati air port and is 22 km from the Gauhati Railway Station in Assam. Its farm is 12 ha in area. The soil is new alluvium with a lower lateritic strata. The pH is 4.4–4.8. The station is 48 m above MSL.

The Substation, Sipighat, is 15 km south of Port Blair in Andamans. It is 5.5 m above MSL and has an area of 32 ha including five ha of mangrove forest. The soil is clay loam with a pH of 5.5 - 6.0.

OBJECTIVES

The main functions of the Institute are: (1) conducting research in the different disciplines related to plantation crops; (2) guiding the research work carried out at the different regional and substations; (3) co-ordinating the work on plantation crops done by the other institutes, universities, and state departments of agriculture; (4) servicing the All India Co-ordinated Projects on Coconut and Arecanut, and on Spices and Cashewnut; and (5) serving as a centre of information on all matters relating to these crops.

ORGANISATIONAL SET UP

The Institute, with its headquarters, two regional stations, and six substations, conducts research on coconut, arecanut, cashewnut, oil palm, cacao, pepper, cardamom, ginger, turmeric, and other spices. It covers the disciplines of agronomy, genetics, soil science, physiology, biochemistry, pathology, microbiology, nematology, entomology, statistics, and extension. The problems in each crop are identified and formulated into time-targeted projects and allotted to a team of two or more scientists after assessing its work load and of the scientists. The Extension Division is responsible for disseminating the research findings, and for organising training on various aspects of plantation crops. Each regional station is in charge of a Joint Director. The substations are in the charge of a Junior Agronomist, a Junior Pathologist or an Assistant Agronomist.

The headquarters of the Institute has a library with more than 2,500 books and 1,500 back volumes. It subscribes to 119 foreign and 70 Indian journals. The library at Vittal consists of 1,911 books, and 639 back volumes, and subscribes to 171 journals. The Regional Station, Kayangulam, has 1,234 books

and 1,600 back volumes and subscribes to 141 journals. The substations are also provided with small libraries and receive 6–12 periodicals each.

During the year, the different experiments that were being carried out under the two All India co-ordinated projects on coconut and arecanut, and spices and cashewnut as well as the four schemes financed from the Cess Fund, were merged with the regular projects of the Institute wherever feasible so as to provide a comprehensive picture of the work in progress at the Institute in different crops irrespective of the source of finance. The results have also been reported accordingly.

SALIENT FEATURES OF WORK DONE

In coconut, four cultivars from Papua, New Guinea, and Surinam were added to the germplasm collection. The cultivars Java, New Guinea, and San Ramon yielded 22-26 kg copra per tree per year as compared to 13 kg given by the local West Coast Tall. The Dwarfs were observed to show a selfing intensity of 47%. Split application of fertilizers to young palms once in two months increased vigour and leaves. Several tuber crops as elephant foot yam, *Dioscorea*, and tapioca were found to do well as intercrops in coconut gardens. Mixedcropping with cacao planted in single or double hedge increased the yield of coconut by up to 50%. Foliar yellowing and rubbery kernel in coconut were found to be associated with low levels of Mg and S in soil and imbalance of nutrient combinations in the leaves. The commencement of bearing in West Coast Tall seedlings was marked by a high carbohydrate reserve and a high carbon/nitrogen ratio in the stem. A preliminary study of the amino acid composition of different varieties revealed the presence of an amino acid tentatively identified as pipicolic acid in the Tall x Dwarf hybrid. A simple process has been developed to deodourise and preserve coconut toddy.

Multidisciplinary investigations were continued on the root (wilt) disease. Inoculation trials on *Physalis minima* with crude and purified root soakate indicated that humid atmosphere favoured the development of disease symptoms. An unidentified fungus, having white mycelium and clamp connections, has been isolated from the root and bark of palms affected by stem bleeding. Efforts to evolve suitable control schedules against the pests of coconut were continued. The sterile male release technique was being tried for the control of the red palm weevil *Rhynchophorus ferrugineus* F. Arprocarb was found to be efficacious in laboratory trials against the grubs of *Oryctes rhinoceros* L.

In arecanut, the cumulative yield data of introductions of *Areca* for nine years continued to show the superiority of seven accessions, *viz.*; VTL-17, VTL-13, VTL-12, VTL-11, VTL-3 (Mangala), Mohitnagar, and Tirthahalli by recording 6–50% increased yield over the local type. Secondary selection was initiated in the variety Mangala to bring phenotypic stability. The optimum spacing for planting arecanut at Peechi (Kerala) was determined to be

2.7 x 2.7 m. Among the six introductions of cacao tried as mixed crop with arecanut at Peechi, cross I 195 x ICS 60 recorded the highest yield. Thermophosphate and Suphala were superior to superphosphate, Factamfos, and ultrafos in releasing available P_2O_5 in the laterite soil of Vittal. Among the green manure crops, *Pueraria javanica* gave the highest tonnage of green matter at Vittal, (Karnataka) and Mohitnagar (West Bengal). Tissue analysis of yellow leaf disease affected palms have indicated nutrient imbalance as cause of this malady. The fungus *Colletotrichum* was found to be associated with 75% of the fallen arecanut buttons and 30% of the buttons collected from the infected inflorescence. Rogor 5% granules applied at 30 kg/ha gave the best control of white grubs. Laboratory studies were initiated with DD-136 nematodes for the control of white grubs.

In cashew, an NPK fertilizer experiment on bearing trees revealed that the main effect N alone was significant for nut yield and weight. It was confirmed that infestation by the tea mosquito *Helopeltis antonii* Sign. was primarily responsible for inflorescence blight and the associated fungi were only secondary saprophytic colonisers. Endosulfan 0. 05% sprayed twice a year at the time of emergence of panicles and again at fruit set controlled the blight effectively.

In pepper, chemical control trials against 'pollu' beetle *Longitarsus nigripennis* Mots. have shown that dimethoate at 0. 1% applied twice, in July and October gave the maximum control of the pest. In turmeric, soil treatment of mephospholan 5% granules @ 9 g per bed of three sq m significantly reduced the incidence of shoot borer *Dichocrocis punctiferalis* Guen. In cardamom, 'azhukal' or capsule rot prevalent in the High Ranges of Kerala could be controlled by spraying with Bordeaux mixture 1% or copper oxychloride 0.2% along with a wetting agent twice a year, in June and August.

The Kidu Farm, Subramanya (South Kanara district, Karnataka) established for the multiplication of genetically superior planting material of coconut, arecanut and cacao made satisfactory progress. Planting of coconut and arecanut was completed in the first block of 60 ha land made available by the Karnataka Government. A second block of 60 ha will be taken over in June, 1974.

A cashew seed farm for the isolation and multiplication of genetically superior planting material was set up at Shantigodu, near Puttur (S. Kanara district, Karnataka State) over 20 ha of land made available by the Karnataka Government. Another 60 ha will be transferred to the Institute by June, 1974.

DISTINGUISHED VISITORS

The Institute, its regional and substations continued to receive a large number of scientists from this country and abroad, government officers, students of universities, and farmers, both individually and in groups. They included

Shri N.N. Wanchoo, His Excellency the Governor of Kerala and Mrs. Chandramohini Wanchoo; Shri Chakkeri Ahamed Kutty, Hon'ble Minister of Education, Kerala State; Shri M.R. Krishna, M.P., Chairman, State Farms Corporation of India; Shri A.G.K. Kodgi, M.L.A., Koondapur, Karnataka; Prof. D.J. Raski, Department of Nematology, University of California, Davis, Ca., U.S.A.; Dr. K.G.H. Shetty, Dean, College of Fisheries, University of Agricultural Sciences, Mangalore; Shri Randhir Singh, Dr. N.K. Panicker, Dr. H.R. Arakeri, Dr. P.Bhattacharya and Dr. S.K. Mukherji, Members, National Commission on Agriculture; Dr. K.N. Raj, Dr. P.G.K. Panicker, Dr. N. Krishnaji and Dr. T.N. Krishnan of Centre for Development Studies, Trivandrum; Dr. P.K. Kymal, Executive Director, Food and Nutrition Board, Ministry of Food and Agriculture, New Delhi; Dr. K. Krishna Rao, School of Biological Sciences, University of London, U.K., Dr. A.B. Borkovec, Insect Chemosterilents Laboratory, U.S. Department of Agriculture, Beltsville, Md., U.S.A., Dr. V.Liyanage, FAO Coconut Agronomist, Indonesia; Dr. E. Ogor, Director, Nigerian Institute for Oil Palm Research; Shri K.T. Chandy, Vice Chairman and Dr. M.V. George, Chief Evaluation Officer, Kerala State Planning Board, Trivandrum; Dr. C.M. Jacob, Vice Chancellor, Dr. K.C. Naik, Adviser and Dean of the Faculty of Horticulture and Dr. M.R.G.K. Nair, Director of Research, Kerala Agricultural University, Trichur; Dr. C.K.N. Nair, Director, Rubber Research Institute of India, Kottayam, Kerala; Dr. James O. Butcher, Program Officer, International Programmes Division, USDA, Beltsville, Md., USA; Dr. H. Schmader, OECD Development Centre, Paris; Mr. P.N. Laudenicia, National Science Development Board, Philippines; Dr. M. Menzi, Swiss Director, Indo-Swiss Project, Mattupatty, Kerala; Dr. T.N. Srinivasan, Central Experimental Station, Centeno, Arima, Trinidad, West Indies; Shri M.G. Sathe, Sathe Biscuit and Chocolate Co. Ltd., Poona, and Shri J. K. Arora, Deputy Commissioner, Mangalore.

IMPORTANT EVENTS OF THE YEAR

The first arecanut variety to be released anywhere, was approved for release by the Central Variety Release Committee under the name MANGALA. It is an introduction from China. It is a semitall variety with early bearing habit, and yields 70% more than the local South Kanara variety.

The work at the Kidu Farm, Subramanya, South Kanara district, was formally inaugurated on 14 April, 1973, by Shri K. Sankara Alva, Minister for Co-operation, Government of Karnataka. Padmashri T.M.A. Pai presided over the function.

The Cashew Seed Farm, Puttur, Shantigodu, South Kanara district, Karnataka, was inaugurated on 10 November, 1973, by Shri K.H. Patil, Minister for Agriculture and Forests, at a meeting presided over by Shri K. Sankara Alva, Minister for Co-operation, Government of Karnataka.

Dr. H. R. Arakeri, Dr. P. Bhattacharya, and Dr. S. K. Mukherji, members of the National Commission on Agriculture, visited the Institute on 27 March, 1973, and held discussions with the scientists. Shri Randhir Singh, M. P., member, National Commission on Agriculture also visited the Institute.

In order to catalyse the transfer of technology to farmers' field the Institute launched a new operational research programme collaboratively with several other agencies for the allround development of a compact block, and as the first step, a bench mark survey of Muttathody village (in Kasaragod NES Block) was carried out.

The Third Group Discussion on the collaborative project on Agrostology was held at the Regional Station, Kayangulam, on 19 November, 1973.

Shri K. V. Ahamed Bavappa, Director, was nominated as a member of the Executive Council of the Kerala Agricultural University.

RESEARCH COLLABORATION AT NATIONAL AND INTERNATIONAL LEVELS

The Institute continued to collaborate with a number of sister institutions and other organisations both at the national and the international levels. The Plant Introduction Division, IARI, continued to assist the Institute in introducing germplasm material from abroad. The Agrostology Project, which is a collaborative effort of the Indo-Swiss Project, Mattupatty, Intensive Cattle Development Project, Mavelikara, and the Department of Animal Husbandry, Government of Kerala, continued to make good progress. Electron microscopic studies on root (wilt) disease of coconut and yellow leaf disease of arecanut were continued at the Nuclear Research Laboratory, IARI, New Delhi, and the Department of Zoology, Kerala University. Dr. O. P. Babbar, Scientist, Central Drug Research Institute, Lucknow, was helping in the investigations on the possible association of mycoplasma with the yellow leaf disease of arecanut and root (wilt) disease of coconut. Dr. G. W. Rahalkar, Scientist, BARC, Trombay, was co-operating with the Institute for testing the utility of the male sterile technique for the control of the coconut red palm weevil. The Commonwealth Institute of Biological Control, Bangalore, supplied cultures of an exotic parasite, *Spoggosia bezziana* Bar. for testing against *Nephantis serinopa M.*

The operational research project of the Institute has been launched in collaboration with several agencies of Kerala State and a few others. These are the Departments of Agriculture, Animal Husbandry, and Co-operation, the Centre for Development Studies, Trivandrum, Small Farmers' Development Agency, NES Block, Kasaragod, Syndicate Bank, Agro-Industries Corporation, Kerala Agricultural University, State Hydrologist, Kerala State Electricity Board, the Rural Engineering Unit, and the Farmers' Training Centre, Taliparamba.

FELLOWSHIPS AND STUDENTSHIPS

Shri M. Sannamarappa, Assistant Agronomist, Substation, Hirehalli, continued to be on study leave for undergoing postgraduate studies in Agronomy. Shri Ramkeshwar Singh, Research Assistant (Agronomy), Substation, Mohitnagar, successfully completed the M. Sc. course in Extension from Agra University. Shri K. P. Vellaichamy, Research Assistant, after taking his Masters' degree in Genetics joined the Ph. D. course at IARI, New Delhi.

OBITUARY

I record with profound sorrow the death of Shri K. Shambu, Nursery Assistant, on 13 February and Shri K. Kandappa, Peon on 6 December.

RESEARCH CONFERENCES

The Staff Research Council met thrice during the year. The Annual Research Council meeting was held at Kasaragod from 19–22 October. The Study Circle, Kasaragod, met 28 times and in addition, organized several lecture classes. At the Regional Station, Kayangulam, 18 meetings of the Study Circle were conducted. The Regional Station, Vittal held 21 meetings of the Study Circle.

MEMBERSHIPS

Shri K. V. Ahamed Bavappa, Director

Member, Executive Council, Kerala Agricultural University,

Member, Coconut Development Council,

Member, Arecanut & Spices Development Council,

Member, Spices Export Promotion Council,

Member, Horticulture Development Council,

Member, Research and Development Cell, Coir Board,

Member, Cacao and its sub-committee, AFCD 39:3 of the Indian Standards Institution,

Member, Scientific Panel of the ICAR for medicinal, aromatic, and plantation crops and

Member, The Agricultural Research Board, the Science and Technology Committee, and the Task Force on Agricultural Production, Kerala Government.

Shri E. V. Nelliat, Head of the Division of Agronomy

Member, Expert Committee to suggest suitable cropping patterns at the Central State Farm, Aralam, Cannanore District.

Shri K. Shama Bhat, Agronomist

Member, Committee appointed by the Karnataka Government to enquire into the causes of the fall in prices of arecanut and suggest remedial measures.

ADVISORY SERVICES

The Institute and all its regional and substations receive a large number of querries on all kinds of problems relating to cultivation practices, spacing and layout, fertilizer and manure recommendations and control of pests and diseases. Requests for site inspections for selection of suitable areas for planting and layout of gardens and for the control of diseases and pests were also being often received. All of them were being attended to, wherever feasible.

EXTENSION

As in previous years, the Institute continued to participate in a number of exhibitions to disseminate the research findings to the public. Among them were those arranged at the Kerala Agricultural University Campus, Trichur, the Central Coconut Research Station, Nileswar, the Koodali High School in connection with the silver jubilee celebrations of the Agricultural Research Station, Koothali, and at the Town Hall, Mangalore on the occasion of the inauguration of the Central Arecanut Marketing & Processing Co-operative Society, which is a joint venture of the Kerala and the Karnataka State governments.

FINANCE

The sanctioned budget, expenditure and revenue for the financial year 1973–74 were as follows:

	Kasaragod	Kayangulam	Vittal	Total
I. SANCTIONED BUDGET				
Non Plan	14,64,300	7,08,000	6,77,700	28,50,000
Plan	13,43,455	3,88,645	3,33,200	20,65,300
A. P. Cess	10,000	20,460	3,50,000	3,80,460
Grant	88,000	—	—	88,000

II. EXPENDITURE

Non Plan	15,17,479	7,86,651	7,34,998	30,39,128
Plan	13,83,670	3,05,440	3,87,752	20,76,867
A. P. Cess	3,850	7,856	4,05,566	4,17,272
Grant	45,657	—	—	45,657
PL 480	—	2,110	—	2,110

III. REVENUE RECEIPTS

5,43,532	82,744	1,46,934	7,73,210

K. V. Ahamed Bavappa

Director

GENETICS

SUMMARY

The cultivars, Java, New Guinea, and San Ramon, yielded 22–26 kg copra per tree per year as compared to 13 kg by West Coast Tall (WCT). The hybrids between Andaman Giant (big nuts) and Laccadive Micro (small nuts) did not show any appreciable increase in copra yield over that of the parents. Dwarf x Tall hybrids identified by seedling characters from the selfed progenies of Chowghat Dwarf Orange flowered within about 62 months. Selfed progenies of Chowghat Dwarf Green showed less variation than those of Chowghat Dwarf Orange indicating a higher heterozygosity in the latter cultivar. Colour of petiole was found to be a useful ancillary character in the identification of D x T hybrid seedlings. Some relatively homozygous Dwarf lines, which will be useful in future breeding programmes were identified. Dwarf segregants from West Coast Tall were meiotically more unstable than West Coast Tall, Dwarf Orange, Dwarf Green and Tall x Dwarf.

Pollination of Chowghat Dwarf Orange with Tall cultivars like WCT, Philippines, and Laccadive Ordinary indicated that the Dwarf showed high selfing intensity (47%). While intraspadix overlapping was the major component responsible for selfing in Dwarf Orange, it was the interspadix overlapping that played a major role in the selfing of Talls. Correlation studies showed that both the number of nuts and copra weight per nut contributed in equal magnitude towards the total yield of copra in WCT palms.

Work in progress

Gen. I (231). **Introduction and study of germplasm material** (R. V. Pillai)

Nut characters of the varieties Karkar and Markham from Papua and New Guinea, and Surinam Tall and Surinam Dwarf from Surinam were studied (Table 1).

Table 1. Nut characters of certain exotic cultivars

Cultivar	Weight of husked nut (g)	Volume of husked nut (ml)	Thickness of kernel (mm)	Wet weight of kernel (g)	Weight of shell (g)	Weight of copra per nut (g)
Karkar	594.7	872.5	10.1	329.0	190.0	156.7
Markham	1342.5	2135.0	9.2	716.0	34.60	313.5
Surinam Tall	571.2	652.5	10.2	315.2	184.2	222.5
Surinam Dwarf	824.2	966.2	10.3	473.5	179.2	274.0
WCT (Control)	572.4	562.5	13.0	316.9	148.2	168.7

Inter se crossing was undertaken in the cultivars San Ramon, Seychelles, Guam, Jamaica, British Solomon Islands, Borneo, Zanzibar, Kenya, Klapawangi, Lono, St. Vincent, Ceylon Tall, Gonthembilli, Rotuma, Standard Kudat, Kendali, King Coconut, Laccadive Micro, Panama, Mpiopong, Blanchissues, Philippines, and Kongthein-yong. *Inter se* progenies of 22 cultivars are being raised.

A comparative yield trial of seven cultivars was laid out in a randomised block design with three replications and four seedlings per plot. The cultivars are Niuleka, Rotuma, Fiji Tall, New Guinea, Lifou Tall, Jamaica, and WCT (*inter se* pollinated material).

Eighty seedlings of Gangabondam (from Ambajipeta, AP), 50 seedlings each of Malayan Dwarf Orange and Yellow and 30 seedlings of Malayan Dwarf Green were planted in Kidu Farm in alternating rows with WCT. In order to raise enough seedlings for the elite seed gardens as well as for yield trials, 4,123 seed coconuts from Lakshadweep, 150 seednuts of Gangabondam and 371 nuts from Andamans were procured and sown.

Seedling measurements taken in 16 cultivars planted in 1972 showed that the cultivars Cochin China, Philippines, Andaman Ordinary, FMS, and Andaman Giant differed significantly from WCT in growth characters like height and length of leaflet. The analysis of yield and associated characters of the cultivars, which have come to full bearing, showed that the cultivar New Guinea, Java, San Ramon, Philippines, Fiji, S. S. Green and Laccadive Ordinary are promising.

Gen. II (231). Exploitation of hybrid vigour

(K. U. K. Nampoothiri, C. K. George, C. K. Sukumaran, and G. Vijayakumar)

Analysis of yield and nut characters of hybrids between Andaman Giant and Laccadive Micro indicated that copra yield was not appreciably higher in the hybrids.

Measurements taken to assess the inter and intra group variability of Tall x Dwarf, Tall x Tall, Dwarf x Tall, and Dwarf x Dwarf seedlings showed that the time taken for germination was significantly low in Dwarf x Tall, the number of leaves was more in Dwarf x Tall and Dwarf x Dwarf, and also that there was no significant difference between the groups for girth at collar.

The second replication of the first set of diallel cross (without reciprocals) involving nine cultivars was planted. Crossing work for a second set of full diallel cross involving seven parents (three Tall and four Dwarf cultivars) was initiated.

From the 300 open pollinated Dwarf Orange seedlings planted for use in standardising the norms of selection, it was observed that very weak Dwarf seedlings could not get established even under proper management.

Since the D x T hybrids have been found to be somewhat tolerant of root (wilt) disease, a crossing programme was initiated to produce different combinations of D x T hybrids to screen them for determining their degrees of resistance, if any.

Gen. III (231). Genetical investigations

(C. K. Sukumaran, K. V. A. Bavappa, Jacob Mathew, K. U. K. Nampoothiri, and R. V. Pillai)

1. Biometric and prepotency studies

Eleven characters were recorded for 63 seedlings planted at Kumbala and 196 seedlings at Goa. At Kumbala, significant family differences were observed for girth, height, length of petiole, breadth of leaf, number of leaflets (left and right), and thickness of petiole. Family VI/4 was conspicuous for higher values for almost all the above characters while they were significantly low for families II/39 and IV/21. Families VIII/13 and VI/143 and IV/25 also showed comparatively higher values. Family differences were not significant for number of leaves produced, number of functioning leaves, and length of leaflet bearing portion. The study is continuing.

At the Goa centre, family differences were significant for height, length of leaflet bearing portion, number of leaflets (left and right), and thickness of petioles. Here the families IV/18, VIII/21, VIII/57, and IV/29 were generally superior to the rest.

Tall x Tall seedlings numbering 525 and 1,400 seedlings from 130 WCT families have been planted family-wise in Kidu and Dharam Vira Farm (both in Karnataka), respectively.

2. Genetics of colour and height

Dwarf seedlings of 40 families of Chowghat Dwarf Orange (CDO) and 25 families of Chowghat Dwarf Green (CDG) were planted in Kidu campus after taking detailed morphological measurements.

The selfed and open pollinated seedlings of CDO could be arbitrarily grouped into three classes, *viz.*, (1) nonvigourous Dwarf seedlings showing little colour variation, (2) vigourous seedlings with high variation in colour, and (3) seedlings which are intermediate in height and vigour, and showing colour variation only. Hybrid seedlings identifiable by the colour change in petiole, vigour, and leaf splitting mostly occurred in the second group. Strong orange yellow colour (10. 0 yr 7/10 or 7. 5 yr 7/4) was quite frequently observed in groups 1 and 3 whereas this was absent in group 2. This indicates the possibility of using colour as an ancillary character for identifying hybrids. The fact that out of 40 selfed families, only two gave dwarfs indicates that most of the CDO palms are not homozygous. The high segregation obtained for height indicate that this character is governed quantitatively.

Seedlings numbering 514 of 28 families of Chowghat Dwarf Green (CDG) were also studied. The seedlings of CDG produced by selfing showed less variability than those of CDO indicating a higher heterozygosity in the latter cultivar.

Similar observations recorded on the seedlings of Kulasekharam Dwarf cultivars showed that Kulasekharam Dwarf Yellow and Kulasekharam Dwarf Orange produced more homozygous population than Kulasekharam Dwarf Green.

The observations that certain nonvigourous Dwarf palms like EB/56 (Dwarf Orange) show only little segregation on selfing is of interest since such lines could be directly made use of for genetical and breeding studies.

To study the genetics of Dwarfs, Talls, and their hybrids height, selfing was done in (1) 12 D x T segregants obtained from CDO, (2) six Tall x Dwarf hybrids and their parents, (3) seven WCT palms segregating for dwarfness and (4) some WCT trees which are nearly homozygous for tallness.

Gen. IV (231). **Cytological investigations in different varieties and forms of *Cocos nucifera* and related species**

(A.A. Mohamed Sayed, M.K. Nair, and G.Vijayakumar)

Meiosis was studied in a few palms of WCT, Chowghat Dwarf Orange (CDO), Chowghat Dwarf Green (CDG), T x D, hybrid Talls segregating, Dwarf progenies, and Dwarf segregants from Tall parents (Table 2). Meiosis

was nearly normal in T x D hybrids. The Segregating Talls, the Dwarf segregant and the Dwarfs showed high frequency of chromosomal aberrations at all stages of meiosis. A higher percentage of pollen sterility was also observed in the dwarf segregant. The frequency of aberrant cells was more in CDG than in CDO. Cytological studies were initiated in Dwarf Orange to examine if the higher mortality observed in their seedlings was associated with gross chromosomal aberrations. The New Guinea palm which is 100% pollen sterile, gave six nuts on pollination with WCT pollen. Only one of them, however, germinated, and the seedling was weak.

Table 2. Meiosis in certain cultivars and hybrids of coconut

S. No.	Variety	Number of trees studied	Chiasma frequency		Percentage of cells with abnormalities at				% age of pollen sterility
			per cell	per bivalent	Diakinesis & metaphase	Anaphase I & II	Telophase I & II	sporad stage	
1.	West Coast Tall	2	28.65	1.78	7.90	7.16	6.33	4.91	6.18
2.	Chowghat Dwarf Orange	1	26.83	1.68	19.11	13.33	8.12	9.74	12.66
3.	Chowghat Dwarf Green	1	26.73	1.67	20.83	13.33	7.33	10.00	13.33
4.	Tall x Dwarf	7	30.15	1.89	4.39	4.59	2.85	1.04	3.27
5.	Segregating Tall	1	27.00	1.69	18.20	11.70	8.1	9.88	12.60
6.	Dwarf segregant	1	26.00	1.62	26.60	20.60	11.66	15.04	43.33

Gen. V (231). **Floral biology: study of pollination and fertilisation**
(G. Vijayakumar, J. Antony, and C. K. Sukumaran)

Observations were recorded on CDO, WCT, Laccadive, and Philippines on the date of opening of inflorescences, commencement, and duration of male and female phases, and their overlapping. The selfing intensity was quantified in these four cultivars and the extent of interspadix and intraspadix selfing worked out. Four formulae were computed with different parameters involved in the observation. The values obtained using the different formulae did not show significant differences (Table 3). A linear relationship was noticeable between the number of female flowers and the duration of female phase.

The CDO showed the highest degree of selfing intensity followed by Philippines, WCT, and Laccadive Ordinary. While intraspadix overlapping was found to be the major component responsible for selfing in Dwarf Orange, it was interspadix overlapping that plays a major role in Talls.

Table 3. Intensity of selfing in four coconut cultivars

Cultivar	No. of trees observed	Mean No. of bunches per tree/year	Mean intensity of selfing * percentage					
			Inter-spadix	Intra-spadix	Total			
					1	2	3	4
Chowghat Dwarf Orange	9	6.8	0.117	0.353	0.470	47.4	46.7	47.5
West Coast Tall	10	16.6	0.128	0.087	0.215	19.9	19.8	21.4
Laccadive Ordinary	10	8.9	0.103	0.078	0.181	19.5	19.3	19.7
Philippines	10	10.2	0.308	0.094	0.402	39.2	36.2	35.1

* Mean intensity of selfing:

Total (1) : $\dfrac{\text{Total number of overlapping female flowers}}{\text{Total number of female flowers}}$

(2) : $\dfrac{\text{Total number of overlapping days}}{\text{Total duration of female phase}}$

(3) : $\dfrac{1}{n} \Sigma \dfrac{\text{Overlapping days for each bunch}}{\text{Duration of female phase for the corresponding bunch}}$

(4) : $\dfrac{1}{n} \Sigma \dfrac{\text{Overlapping female flowers for each bunch}}{\text{No. of female flowers in the corresponding bunch.}}$

where n is the total number of bunches

Gen. VII (231). **Mutation breeding**

(A. A. Mohamed Sayed)

Pollen sterility, pollen size, pollen germination, and growth of germinating pollen were studied in 34 M_1 and nine control trees. A progressive increase in the rate of pollen tube growth was observed when the dose of pollen

irradiation increased from 30 kr to 50 kr, and thereafter, it registered a sharp decrease. The highest pollen sterility observed was 52.8% and here the pollen germination was only 39.1%. The M_1 trees showed variation in the production of spadices and in the time taken for flowering. So far, 138 M_2 seedlings have been planted at the Regional Station, Kayangulam, to study their reaction to root (wilt) disease.

Gen. VIII (231). **Evolution of an ideal plant type**

(K. Satyabalan, K. V. A. Bavappa, Jacob Mathew, K. U. K. Nampoothiri, A. Ramadasan, and C. K. Sukumaran)

The special protractor devised for measuring the angle of disposition of leaves on the crown of the palms was suitably modified to facilitate easier manipulation. A palm of medium height having 29 functioning leaves was selected and the angles of incidence of the leaves were measured using this instrument. It varied from 3° (the youngest opened leaf) to 115° (the oldest functioning leaf). There was a progressive decrease in the angles of leaves from the oldest to the youngest. Data on the yield attributes like inflorescence production, female flower production, yield of nut, copra weight per nut, and copra yield of selected high yielders gathered to fix the parameter of an ideal plant type in coconut showed that, in general, regular spadix production and high female flower production contributed to high yields in coconut.

Correlation studies conducted using 32 high yielding palms of WCT indicated that both number of nuts and copra weight per nut contributed in equal magnitude towards the total outturn of copra of a palm. Studies are continuing using larger numbers of palms. The values obtained were $r_{XY} = 0.207$; $r_{XZ} = 0.633$; $r_{YZ} = 0.615$; $r_{YXZ} = 0.990$; and $r_{XYZ} = 0.985$, where X = number of nuts, Y = copra weight per nut, and Z = copra yield.

All India Co-ordinated Project

Seedlings have been produced from *inter se* crossed seeds of the Andamans cultivars, and from hybrid seeds received from Ratnagiri involving Gangabondam, Fiji, Laccadive Ordinary, and Philippines and also those received from Veppankulam involving Laccadive Ordinary, Philippines, and Cochin China.

A diallel crossing programme involving three Tall (including Andaman Ordinary) and four Dwarf cultivars was initiated. An yield trial with eight cultivars collected from the Andaman and Car Nicobar Islands was laid out at the CPCRI Substation, Andamans. The coconut seedlings planted at Ambajipeta, Mahua, Coimbatore, Mohitnagar, and Ratnagiri to evaluate the performance of promising cultivars/hybrids under different agroclimatic conditions are establishing satisfactorily.

Table 4. PROGRAMME OF WORK (GENETICS) FOR 1974

Project No.	Name of the Project	Venue
Gen. I (231)	Introduction and study of germplasm	Kasaragod, Kayangulam, Nileswar, Andhra Pradesh, Lakshadweep, and Andaman Islands
Gen. II (231)	Exploitation of hybrid vigour	Kasaragod, Kayangulam, Nileswar, Kidu, and Mangalore
Gen. III (231)	Genetical investigations	Kasaragod, Goa, Gonicoppal, Kumbala, and Kidu
Gen. IV (231)	Cytological investigations in different varieties and forms of *Cocos nucifera* and related species	Kasaragod
Gen. V (231)	Floral biology: study of pollination and fertilisation	Kasaragod
Gen. VI (231)	Developmental anatomy of the crown of *Cocos nucifera*	Kasaragod
Gen. VII (231)	Mutation breeding	Kasaragod and Kayangulam
Gen. VIII (231)	Evolution of an ideal plant type for coconut	Kasaragod and Kidu
All India Co-ordinated Project		
Experiment 3	Trial of promising seed material	Kasaragod, Coimbatore, Mahua, Ambajipeta, Mohitnagar, and Veppankulam
Experiment 4	Evaluation of Tall x different Dwarfs	Kasaragod, Nileswar, and Ambajipeta

AGRONOMY

SUMMARY

During the prebearing stage, nitrogen improved the rate of leaf production, while phosphorus increased the number of functional leaves. The rate of leaf production was higher and the attainment of bearing earlier in D x T hybrids, indicating higher efficiency of these hybrids over T x D or high yielding Talls. An experiment was initiated to assess the quantum of fertilizers required in the first year by the adult palms grown under neglect. Bimonthly split application of fertilizers to young palms resulted in high rate of leaf production and vigour as compared to application at wide intervals.

As a measure to increase the productivity of land, a large number of tuber crops, pulses, and oilseeds were under trial as intercrops. Tuber crops in general performed the best. Elephant foot yam, *Dioscorea*, and tapioca yielded respectively 12.1, 10.7 and 7.7 tons per ha. Cacao also proved to be equally successful in that yield of coconut in this plot increased by 40–50%. The lateral spread of cacao roots was upto 80 cm only thus it was competing only minimally with coconut.

Fertilizer application to nursery beds produced seedlings with increased vigour and higher nitrogen and chlorophyll content in the leaves. The fodder cum legume plots showed increased exchangeable potassium and microbial activity. In the root (wilt) affected area, they produced an overall visual improvement of the palms and 23% more nuts.

Work in progress

Agr. I (231). Nutritional requirement of coconut under different soil types

(E. V. Nelliat, K. Shama Bhat, and A. K. Sadanandan)

1. NPK fertilizer experiment on young palms in sandy loam soil

Initiated in 1965, the object of this experiment is to determine the NPK requirement of the WCT variety from the early stages of growth. It is laid out in a 3^3 confounded design. The fertilizer levels are 500, 750, and 1000g N, 500, 1000, and 1500 g P_2O_5 and 750, 1500, and 2250 g K_2O per palm per year. A treatment with no manuring at all was also included during the year. The fertilizers are applied in two splits, *viz.*, one-third in May and the rest in September.

The growth characters recorded in June showed that N improved leaf production significantly. Phosphorus enhanced the number of functional leaves. The NP interaction was also significant for the above two characters. The highest number of leaves, *viz.*, 70 was produced in the treatment N_3P_3. Nitrogen at the third level and at medium level resulted in the highest number of 21 functional leaves. Potash alone and NK or PK interactions had no significant effect on the growth characters studied.

Up to the end of December, 86/140 palms had flowered. The study is continuing.

2. Fertilizer response of young palms of high yielding types

This experiment was started in 1965 to study the fertilizer requirements of high yielding WCT, D x T, and T x D palms from the time of their planting in the field. The treatments consist of three levels of NPK mixture, *viz.*, no fertilizers (m_0), 500g N + 500g P_2O_5 + 1000g K_2O (m_1) and 1000g N + 1000g P_2O_5 + 2000g K_2O (m_2) per palm, per year. A randomised block design with nine treatments and three replications has been adopted with six palms per plot. The fertilizers are applied in two split doses, *viz.*, one-third in May and two-thirds in September.

Observations on leaf production, number of functional leaves, length of leaf, length of petiole, and length and breadth of leaflets recorded in June showed highly significant differences between palms receiving m_0, m_1, and m_2 treatments. The D x T hybrid produced maximum number of 76 leaves, as compared to 64 leaves by high yielding Tall and 59 by the TxD hybrid. While most of the palms receiving fertilizer have flowered, only 22% of the palms in the no fertilizer treatment have flowered. The experiment is continuing.

3. Fertilizer response of palms growing under neglected conditions

This experiment was initiated during the year to study the effect and economics of application of graded doses of NPK to adult palms grown under neglected condition. The palms aged about 20 years, and yielding about 20 nuts annually were used. The experiment consists of six treatments (Table 5).

Table 5. Fertilizer schedules to study the response of palms growing under neglected conditions

	Year				
	First	Second	Third	Fourth	Fifth
T_1	nil	nil	nil	nil	nil
T_2	1/3F*	2/3F	F	F	F
T_3	1/2F	F	F	F	F
T_4	F	F	F	F	F
T_5	2F	F	F	F	F
T_6	2F	2F	F	F	F

*** F is the full recommended dose of fertilizer for the Tall variety coconut, 1.1 kg urea + 1 kg ultraphos or rock phosphate + 2 kg muriate of potash**

A randomised block design with four replications and six palms per plot was adopted. The experiment was begun in September.

4. NPK fertilizer experiment in major soil types of different agroclimatic regions on ordinary Tall variety

i) *Littoral sand at Kasaragod.* This experiment was initiated in October, 1972, using one year old seedlings. For improving moisture retention, about 150 dry coconut husks and .027 cu. metre red earth were applied to each pit. The fertilizer treatments consist of all combinations of three levels of N,P, and K, *viz.*, 500, 1000 and 1500 g N; 250, 500, and 750 g P_2O_5; and 750, 1250, and 1750 g K_2O per palm per year. There are also three additional treatments, *viz.*, absolute control, $N_1P_1K_1$+Ca+Mg, and $N_3P_3K_3$+Ca+Mg. The dosages of Ca and Mg are @ 150g, and 300g respectively. The young palms receive one-third the adult dose in two splits, in May and September. The experiment is continuing.

ii) *Forest soil at Sipighat (Andamans).* A similar experiment as above was laid out here also.

5. Nutritional requirement of high yielding coconut varieties and hybrids

The hybrids and some introductions like Laccadive Ordinary possess high yield potential and the nutritional requirements of such varieties are

expected to be greater than those of the Tall variety. This experiment laid out in 1972, aims at determining the NPK,Ca, and Mg requirements of the Laccadive Ordinary variety from the early stages of growth. A $3^3 \times 2$ confounded split-plot design with Ca+Mg as subplot treatments has been adopted. The treatments consist of all combinations of three levels each of N,P and K with two levels of Ca and Mg. The fertilizer nutrient levels are 1000, 1500, and 2000 g N; 500, 750 and, 1000g P_2O_5; 1250, 1750 and 2250 g K_2O; 150, and 300 g CaO, and 150 and 300 g MgO.

The first year dose of fertilizers was given in two splits. The experiment is continuing.

Agr. II (231). Irrigation and drainage problems: water requirement

(E.V. Nelliat and C.K.B. Nambiar)

1. Irrigation cum fertilizer experiment from early stages of growth

This experiment aims at determining the optimum quantity and interval of irrigation and also the fertilizer requirement of palms growing under irrigated condition. It was laid out in 1968 in a 3^3 confounded design with two replications. The irrigation treatments are three depths of irrigation (4mm, 8mm and 16mm) and three intervals of irrigation (4, 8 and 12 days). Irrigation was given from December to April. The three levels of fertilizer mixture are (m_1): 500g N, 330g P_2O_5, 750g K_2O and 170g MgO; (m_2): 750g N, 670g P_2O_5, 1500g K_2O and 170g MgO; and (m_3): 1000g N, 1000g P_2O_5, 2250g K_2O and 170g MgO per palm annually.

Leaf production, number of functional leaves, and length and breadth of leaflets were recorded in June. Irrigation at four day interval resulted in the highest rate of leaf production and maximum functional leaves. Although higher levels of irrigation water benefitted the above two characters, the differences between treatments were not significant. The growth characters also improved significantly with higher levels of fertilizer dosages.

Results of soil moisture determinations carried out during March-April (Table 6) showed that the moisture status of the top 0-15 cm layer soil touched the wilting point in all the treatments.

Up to end of December, 87/248 experimental palms had flowered.

The experiment is continuing from December with a modified irrigation treatment *viz.*, 20mm, 40mm, and 60mm depths of irrigation at IW/CPE (Irrigation Water/Cumulative Pan Evaporation) ratios 0.50, 0.75, and 1.00.

2. Drought tolerance of hybrids and varieties

The observational plot was planted in 1971. Bimonthly applications of an NPK mixture to supply annually 100g N, 50g P_2O_5, and 200g K_2O were carried out. The mean number of leaves produced and the number of

Table 6. Effect of depth of irrigation water and intervals between irrigation on soil moisture content

Depth of irrigation	Depth of soil layer	Moisture content (%) on oven dry weight basis*			
		Intervals between irrigations			
		2 days	4 days	6 days	Mean
4 mm	0–15 cm	4.5	3.6	4.0	4.0
	15–50 cm	7.0	5.3	5.1	5.8
8 mm	0–15 cm	4.3	4.0	4.1	4.1
	15–50 cm	6.0	5.4	5.1	5.5
16 mm	0–15 cm	4.5	3.9	4.3	4.2
	15–50 cm	6.0	5.6	6.0	5.9
Mean	0–15 cm	4.5	3.9	4.3	4.2
	15–50 cm	6.3	5.4	5.4	5.7

* Field capacity – 10.8%

functional leaves observed in December were: Laccadive Ordinary-25 and 11; TxD-20 and 8; TxG-21 and 8; DxT-21 and 8; and Tall-19 and 7 leaves.

3. Efficacy of different soil moisture conservation measures

This trial was laid out in 1972 using adult bearing palms growing in loamy sand. A randomised block design with six treatments and four replications was used. The treatments are (1) control; (2-5) mulching an area of two m radius around the base of palms with dry coconut leaves, coffee husk, coconut husk and vermiculite; and (6) burying coconut husk (1000 husks per palm) and leaves in 150 cm broad and 40 cm deep trenches in between rows of palms. The experiment was continued.

Agr. III (231). Cultural cum spacing trials

(E.V. Nelliat, A.K. Sadanandan, and A.M. Shetty)

1. Long term effect of cultivation and manuring

These observation plots set up in 1919 to study the long term effect of neglect (P_1) on growth and yield of palms as compared to regular intercultivation alone (P_2), and manuring plus intercultivation (P_3). The intercultivation consists of two harrowings in September and October. Manuring consisted of 1 kg urea, 1 kg ultraphos, 2 kg muriate of potash, and 50 kg green leaf per tree annually.

The treatments were modified in 1972 by halving the three plots and giving new treatments to the newly formed three plots (Table 7). Earlier, in 1967, the plots had been underplanted with WCT seedlings.

The yield data for 1973 of the yielding palms and the growth characters of the young palm are given in Table 7.

Table 7. Long term effects of no cultivation and no manuring on yield and growth characters of palms

Treatments	Nut yield of bearing palms	Young palms growth characters		
		No. of leaves produced	No. of functional leaves	No. flowered
1. No cultivation and no manuring (P_1)	23.3	30.2	5.2	
2. Chemical weed control	23.5	30.0	5.6	
3. Cultivation alone (P_2)	29.0	37.0	7.3	
4. Fertilizer application and forking	31.3	38.7	10.7	
5. Cultivation plus inorganic fertilizers plus green leaf (P_3)	59.8	49.5	18.5	3
6. Cultivation plus inorganic fertilizers	48.0	49.5	17.1	

2. Spacing cum method of planting experiment

This experiment laid out at Kidu Campus in 1972 aims at evaluating the efficacy of different planting systems and determining the optimum palm density. The treatments consist of four methods of planting, *viz.*, square, triangular, single hedge, and double hedge and palm densities range from 138 to 357 per ha. The trial has 18 treatments. The gross plot size is 0.25 ha. It has been laid out in a randomised block design with two replications.

Agr. IV (231). Inter and mixed cropping trials with annual and perennial crops

(P. K. R. Nair, E. V. Nelliat, and Rama Varma)

1. Intercropping trials

Tapioca and elephant foot yam, continued to show themselves as valuable intercrops in coconut gardens.

A large number of annual crops were screened to assess the feasibility of raising them as rainfed intercrops. These included pulses (black gram, bengal gram, horse gram, soybean, and cow pea), tuber crops (*Dioscorea alata*,

Dioscorea esculenta, coleus, and colocasia), sun flower and ground nut. They were raised according to their respective recommended package of practices.

Soybean and bengal gram were inoculated with rhizobial cultures. The crops were sown in September-October after the north-east monsoon. They germinated well, but did not establish and yield properly. They were also adversely affected by the long spell of drought after the north-east monsoon which coincided with the flowering of these crops. Trials will be continued to see if they could be raised successfully by modifying the agronomy of these crops.

Tuber crops, however, appeared to be promising. *Dioscorea alata*, *D. esculenta*, coleus, elephant foot yam, and tapioca gave satisfactory yields (Table 8).

Table 8. Performance of some tuber crops as intercrops in coconut gardens

Intercrop	Percentage of gross area utilised for inter-cropping	Variety	Gross area sown (in sq m)	Yield (kg)	Yield (kg/ha of gross area)	Yield (kg/ha inter-cropped area)
Tapioca	82	M_4	3000	2300	7.7	9.4
Elephant foot yam	82	Local	4040	4902	12.1	14.8
Dioscorea alata	82	Local	420	450	10.7	13.1
Coleus	75	Local	180	108	6.0	8.0
Dioscorea esculenta	82	Local	56	45	8.0	9.8

Sunflower was tested in two seasons, July and October. The July sowing gave only a poor stand of the crop owing to dripping of water from coconut leaves and cloudy weather. Plants sown in October showed satisfactory growth and flower production. The study is continuing.

Coffee is proposed to be taken up as mixed crop. Seedlings of the Robusta variety S.274 obtained from the Coffee Research Station, Balehonnur, Karnataka, were planted in a secondary nursery in August. They will be transplanted in the coconut garden later.

2. Mixed cropping trials with cacao

This trial was laid out in 1970 and consists of three treatments and seven replications. The treatments are (1) control – no mixed crop; (2) single

hedge planting of cacao; and (3) double hedge planting of cacao. The coconut palms consist of varieties about 20 year old and the cacao was planted in 1970.

Since 1966, they are being fertilized at the higher rate of 1.00 kg N, 0.64 kg P_2O_5, 2.40 kg K_2O per palm per year applied in two splits, in May and September. Cacao plants are fertilized at the rate of 100g N, 40g P_2O_5, and 140g K_2O per plant per year applied in two equal splits. After planting cacao in 1970, the plot is being sprinkler-irrigated during the dry months of December-May at weekly intervals, at the rate of 2.8 cm per irrigation.

Ninety five percent of the cacao plants have flowered. Plants in the replications VI and VII are relatively stunted and less vigourous, but soil and tissue analyses did not reveal any marked difference in nutrient content as compared to the other replications. It is not known if the plants are adversely affected by the constantly blowing sea breeze. The growth and yield characters of cacao in the mixed cropping experiment is given in Table 9.

Table 9. Growth and yield characters of cacao in the mixed cropping experiment*

Characters	Single hedge	Double hedge
Girth at collar (cm)		
July '71	10.3	10.3
July '72	15.4	15.1
July '73	22.4	21.9
Plot yield		
Total number of pods	82	151
Total fresh weight of pods (kg)	26.2	46.2
Total wet weight of beans (kg)	8.4	13.5
Plant yield		
Average number of pods	4.6	4.6
Average fresh weight of pods (kg)	1.5	1.4
Average weight of beans (kg)	0.5	0.4

*** Data from replications I to V only**

The growth and yield of cacao plants were marginally more under the single hedge of planting but since the double hedge system of planting provides for nearly double the number of plants per unit area, the total yield of cacao per plot was considerably more with the double hedge system of planting.

The yield of coconut has also increased substantially in recent years (Table 10). The study is continuing.

Table 10. Yield of coconut in the mixed cropping experiment of coconut and cacao

Treatment	Yield of nuts per palm per year		
	Before planting cacao (1966–70)	After planting cacao (1971–73)	Increase in yield (%)
Control	68	112	44
Single hedge of cacao	57	107	50
Double hedge of cacao	39	80	41

3. Mixed cropping with tree spices and pepper

Cinnamon and black pepper planted in adult coconut plantations are making satisfactory growth. Growth of clove and nutmeg continue to be slow. The study is continuing.

4. Multistoreyed cropping

The observational trial of multistoreyed cropping initiated in 1970 using cacao, black pepper, and pineapple is in progress, with no adverse effect on coconut. The crops are just coming to the bearing stage.

Root spread of cacao in this plot showed that the roots of 3½ years old plants are confined to an area of one m and 80 cm laterally with maximum root concentration at 20-60 cm region.

A field experiment on multistoreyed cropping laid out in 1972 and involving five crop combinations, progressed satisfactorily. A few cacao and pepper plants and most of the pineapple plants have flowered.

5. Intercrop relations

Encouraged by the promising results obtained in the observational trials with tuber crops as intercrops in coconut gardens, a new field experiment was initiated during the year using five rainfed intercrops in rotations, to study the economics of raising them in suitable annual rotations and their effect on the main crop. The proposed schedule are given in Table 11.

The trial has been laid out in a randomised block design with three replications with a gross area of about 0.1 ha per plot. All crops were raised according to the recommendations for the pure crop of each. Sweet potato was harvested in late September, the plot was divided into two equal halves, and black gram and horse gram (local varieties) were sown in them. The study is continuing.

Table 11. Proposed schedule of the rotation experiment with tuber crops as intercrops

First year	Second year	Third year	Fourth year	Fifth year
Elephant foot yam	Sweet potato + Pulses	Turmeric	Tapioca	Ginger
Tapioca	Turmeric	Elephant foot yam	Ginger	Sweet potato + Pulses
Sweet potato + Pulses	Ginger	Tapioca	Turmeric	Elephant foot yam
Ginger	Tapioca	Sweet potato + Pulses	Elephant foot yam	Turmeric
Turmeric	Elephant foot yam	Ginger	Sweet potato + Pulses	Tapioca

Agr. V (231). **Nursery studies: standardisation of selection indices**
(P. K. R. Nair, E. V. Nelliat, and the late K. Shambu)

This experiment, initiated in 1971, was completed during the year. The objects were (1) standardising selection criteria for differentiating quality seedlings earlier than at the usual age of 9-12 months; (2) determining the best time of harvest of the seednuts; and (3) determining the fertilizer requirements of seedlings. Seed coconuts collected every month for 12 months from June, 1971 to May 1972 were sown in nursery, two months after harvest. There were eight fertilizer treatments consisting of different combinations of N, P, K, Ca, and Mg with three replications and 16 seednuts per treatment.

Seednuts collected during April to July germinated in less than 125 days after sowing whereas those collected during September-January took 160-180 days for germination. The total germination percentage and the chlorophyll content of leaves were not affected by the month of harvest. The seednuts collected during April-August produced seedlings with significantly more leaves, leaf area and girth at collar and height, indicating that they were more vigourous in growth. Application of N, P, and K in combination with Ca and Mg gave seedlings with increased vigour, and higher nitrogen and chlorophyll content of leaves.

Seedlings from four fertilizer treatments, $N_0P_0K_0$, $N_1P_1K_1$, $N_1P_1K_1Ca_1Mg_1$, $N_3P_3K_3Ca_3Mg_3$, and control, have been planted in cultivators' fields for follow up studies to observe the growth and performance of the palms. Seedlings have established well. The study is continuing.

Agr. VI (231). **Cost of production**

(C. A. Kunhiraman, Rama Varma, and P.K.R. Nair)

This is being calculated from a 0.62 ha plot planted with the WCT variety and managed under recommended dose of fertilizers and cultural operations. Of the 91 palms in the plot, 83 have commenced bearing and 51 have stabilised their yield. The total cost of cultivation for the entire plot during 1972-73 worked out to Rs. 770.00. This worked out to Rs. 1,243.55 per ha of a plantation that has just commenced bearing. Based on the yield of nuts from palms of stabilised yield, the annual cost of cultivation worked out to Rs.156.15 for producing 1000 nuts.

Agr. VII (231). **Agrostology: mixed farming in coconut garden: raising fodder grass and maintaining milch cows**

(K. N. Sahasranaman, N. G. Pillai, N. P. Jayasankar, Thomas Varkey, P. G. Kamalakshy Amma, Rama Varma, and M. K. Muliyar)

Collaboration **Indo Swiss Project, Mattupatty and Intensive Cattle Development Project, Kerala**

The project was begun at Kayangulam in 1970 to develop a system of alternate husbandry in coconut garden with fodder grass and legume as intercrops, and to study its effect on root (wilt) affected palms and the economics of mixed farming. At Kayangulam, the fodder grass hybrid napier and the legumes *Stylosanthes gracillis*, *Pueraria javanica*, and *Centrosema pubescens* have been raised under irrigated conditions in an area of 1.3 ha and eight milch cows (F_1 of Brown Swiss and local cattle) are being maintained.

The usual recommended management practices were carried out for fodder crops and coconut palms. Leaf blight was observed in hybrid napier grass in most of the plots and prompt control measures were adopted. Some slips of *Setaria* (variety Nandi), guinea grass, and hybrid napier NB 21, were also planted during the year. Some pepper cuttings (variety Panniyur 1) were also planted in the area and trained on coconut palms.

Physico chemical properties

Though aggregate analysis has revealed differences between post and pre treatment values, especially in mesh sizes 2.0 mm, the differences among the seven treatments were not statistically significant for any of the mesh sizes.

Available K, was significantly high in the top 50 cm of the soil as compared to the lower levels. Potassium content was comparatively high in legume plots also and it was the lowest in the hybrid napier plots.

Microbial activity

Considerably higher populations of both bacteria and nitrogen fixing organisms were obtained in plots cultivated with grass and *S. gracillis* and *C. pubescens*. For cellulolytic organisms, higher populations were recorded in the plots cultivated with grass, *S. gracillis* followed by that cultivated with *P. javanica*. Maximum populations of denitrifiers, were obtained in the plot of grass with *C. pubescens* followed by grass with *P. javanica* and *S. gracillis*.

Foliar condition of palms in relation to root (wilt) disease

Observations showed that there is no reduction in the intensity of disease symptoms like flaccidity and necrosis were observed, but the intensity of yellowing was reduced.

Yield of palms

Apparently healthy palms and those in early stages of disease showed an increase of 25.9% in yield of nuts. It was 14.7% in palms at middle and advanced stages of disease. The overall increase in yield was 23%.

Dairy unit (Kayangulam)

The eight milch cows produced 13148 *l* of milk during the period which was valued at Rs. 18,040.50. A statement showing the receipts and expenditure is given below in Table 12.

Table 12. Receipts and expenditure of the mixed farming project, Kayangulam

Expenditure		Receipt	
Capital	15,919.00	Cost of milk	18,040.50
Recurring	13,340.00	By sale of grass	194.00
Interest on capital	1,847.00	By sale of gunnies	82.95
Depreciation on capital investment at 5%	950.00	Cost of cowdung	1,705.00
	16,137.00		20,022.45

Dairy unit (Kasaragod)

At Kasaragod, three more animals were added during the year bringing the total number to six. They produced 7855.5 *l* of milk which realised Rs. 11,994.93. The farmer family which was looking after the dairy unit earned an income of Rs. 5,005.85 paid as wages.

The yield of fodder grass and legumes (hybrid napier and *Stylosanthes* sp.) from the 1.8 ha experimental area was 54330 kg. The growth of the fodder plants under young palms was comparatively poor possibly due to the shade effect. The nutrient status was not significantly altered by the fodder cultivation. Cost accounting will be done after another year.

Agr. VIII (231). **Meteorological observations and microclimatic studies**

(T. K. Balakrishnan and P. K. R. Nair)

The meteorological data for Kasaragod are presented in Table 13. The south-west monsoon commenced on 5th June. A total precipitation of 2857.0 mm was received during the year against the 20 year average of 3561.6 mm.

The microclimatic observations on relative humidity, vapour pressure, and evaporation were observed for coconut (varieties Tall and Dwarf), cacao, and cinnamon. Daily observations were recorded from February at 07.00 and 14.00 hrs at 0, 60, and 120 cm height from ground level for all plants and also at crown height and inside the crown of coconut palms.

Fluctuations of relative humidity and vapour pressure at different heights of the coconut palm were almost of the same magnitude as those in the observatory. In the case of cacao and cinnamon, the differences between relative humidity and vapour pressure in forenoon and afternoon were narrower. The relative humidity at the surface was also higher in cacao and cinnamon. For all the crops, the vapour pressure was lower at increasing heights and evaporation at 60 cm height was higher as compared to the ground level.

Soil samples were collected at monthly intervals one m away from the base of these plants at 0–15 and 15–50 cm depths and their moisture percentage determined gravimetrically. Soil moisture depletion was more from the 0–15 cm zone. Also, under identical conditions, the soil moisture content was comparatively higher around cacao than around cinnamon.

At Kayangulam, the total rainfall during the year was about 20% below normal with 1906.7 mm on 113 rainy days as against a six year average of 2484.8 mm in 123 rainy days. The monthly mean of maximum daily temperature ranged between 34.8°C in March and 29.8°C in August, and the monthly mean of daily minimum varied between 28.9°C in January and 25.8°C in April. The monthly average of maximum and minimum daily hours of bright sunshine recorded was 10.6 hr in February and 3.7 hr in August.

By using an Assman Psychrometer, daily observations were recorded at 07.24 and 14.24 hr in the observatory upto a height of 3.7 meters (12 feet). The meteorological data for Regional Station, Kayangulam are given in Tables 14 a, b, and c. The study is continuing.

Table 13. WEATHER DATA, KASARAGOD, 1973

	Month	RAINFALL						TEMPERATURE (°C)						HUMIDITY	
		1973		1972		20 years' average		Maximum			Minimum				
		Amount (mm)	No. of rainy days	Amount (mm)	No. of rainy days	Amount (mm)	No. of rainy days	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest
N. E. monsoon	January	0.0	0	0.0	0	0.8	0.1	33.3	29.4	31.1	23.3	18.0	20.0	93	75
		0.0	0	0.0	0	0.8	0.1								
Hot weather rains	February	0.0	0	0.0	0	0.0	0.0	36.9	30.9	32.7	24.0	19.5	21.7	95	71
	March	0.0	0	0.0	0	3.7	1.1	33.5	30.9	32.5	24.7	20.0	22.8	95	81
	April	1.4	0	12.0	1	47.2	2.3	34.6	33.0	34.0	27.5	24.0	25.9	91	71
	May	86.2	5	306.3	12	267.3	9.0	34.0	29.2	33.2	27.0	21.6	25.1	93	59
		87.6	5	318.3	13	318.2	12.4								
S. W. monsoon	June	659.4	28	894.7	11	975.6	20.0	32.8	26.9	29.8	25.8	21.0	23.6	97	74
	July	810.0	23	1004.9	27	1056.1	29.0	31.0	27.0	28.8	24.5	22.0	22.8	97	85
	August	918.9	29	502.1	26	615.7	21.5	29.2	24.5	27.0	21.8	21.8	22.3	97	90
	September	152.0	10	119.4	8	305.3	12.0	30.6	29.1	29.3	24.0	21.5	22.5	97	83
		2540.3	90	2521.1	72	2952.7	82.5								
N. E. monsoon	October	122.4	10	208.2	13	198.9	9.7	33.6	27.1	30.3	24.2	20.0	22.6	98	80
	November	56.2	4	12.7	1	73.9	4.2	33.5	30.8	31.5	24.0	17.5	21.5	95	69
	December	50.5	2	15.2	2	17.1	1.5	33.8	27.8	31.8	22.2	16.0	19.9	96	95
		229.1	16	236.1	16	289.9	15.4								
Grand Total		2857.0	111	3075.5	101	3561.6	110.4								

SUNSHINE (hr)			WIND VELOCITY (km/hr)			USA PAN EVAPORATION (mm)		
Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average
10.3	4.7	8.6	2.7	1.0	1.9	5.6	3.1	4.4
10.3	6.3	9.9	5.0	0.8	2.5	4.9	3.6	4.4
10.3	5.9	9.6	2.6	1.9	2.1	6.2	-3.9	5.1
11.0	5.2	8.8	2.9	1.6	2.5	4.8	3.7	4.2
10.9	1.0	9.0	3.5	0.6	2.2	4.7	0.0	4.2
10.3	0.0	3.7	5.1	0.5	2.0	6.8	0.0	4.0
10.8	0.0	5.2	Data not available			4.7	0.0	4.2
8.3	0.0	4.1	,,	,,	,,	4.4	0.0	3.5
10.3	1.5	7.3	,,	,,	,,	4.4	1.2	4.1
10.3	0.9	6.3	,,	,,	,,	4.6	1.3	3.1
10.1	2.1	8.7	,,	,,	,,	4.6	3.5	4.5
10.9	0.3	8.5	,,	,,	,,	5.6	1.0	4.0

Table 14 b. VARIATION IN RELATIVE HUMIDITY, KAYANGULAM, 1973

Month	TIME OF OBSERVATION: 07.24 hr						TIME OF OBSERVATION: 14.24 hr					
	Surface	Height					Surface	Height				
		0.31 m	0.61 m	1.23 m	2.46 m	3.70 m		0.31 m	0.61 m	1.23 m	2.46 m	3.70 m
January	87	87	86	86	85	85	55	54	53	55	55	55
February	84	83	83	83	83	83	52	50	50	50	52	52
March	82	81	81	83	82	83	54	53	52	53	54	55
April	88	87	86	86	85	85	64	63	63	64	64	64
May	88	88	87	86	86	86	63	61	61	62	62	62
June	91	90	89	89	89	89	79	78	77	77	77	77
July	92	92	92	92	91	92	79	79	78	77	77	79
August	93	93	93	92	92	93	80	79	79	78	78	77
September	91	91	90	90	90	90	71	69	69	69	69	69
October	93	93	92	91	91	91	72	72	71	71	71	71
November	91	91	90	90	90	90	63	64	64	64	65	65
December	90	89	88	87	87	87	61	60	60	61	61	61

Table 14 c. VARIATIONS IN VAPOUR PRESSURE, KAYANGULAM, 1973

Month	TIME OF OBSERVATION: 07.24 hr						TIME OF OBSERVATION: 14.24 hr					
	Mean vapour pressure (mm) at different heights						Mean vapour pressure (mm) at different heights					
	Surface	0.31 m	0.62 m	1.23 m	2.46 m	3.70 m	Surface	0.31 m	0.62 m	1.23 m	2.46 m	3.70 m
January	18.4	18.4	18.3	18.1	18.0	17.8	21.7	21.0	20.4	20.1	19.8	19.6
February	20.0	19.8	19.6	19.6	19.5	19.5	21.3	20.4	20.3	22.4	19.8	20.0
March	21.9	21.7	21.6	21.6	21.5	21.8	22.9	22.6	21.9	21.3	20.6	21.6
April	24.7	24.6	24.1	23.9	23.6	23.7	25.6	25.1	24.5	23.9	23.6	23.7
May	24.7	24.4	24.0	23.9	23.7	23.7	25.2	24.1	23.6	23.1	22.7	22.4
June	23.6	23.2	22.9	22.8	22.8	22.7	25.3	24.9	24.2	23.8	23.6	23.6
July	23.0	23.0	22.8	22.8	22.7	22.7	25.7	25.1	24.3	24.1	23.7	23.6
August	22.5	22.5	22.2	22.1	22.0	22.1	24.5	24.0	23.3	22.9	22.7	22.5
September	22.9	22.9	22.7	22.7	22.6	22.6	24.5	23.8	23.3	23.0	22.7	22.6
October	23.3	23.0	22.8	22.7	22.5	22.5	24.5	23.9	23.1	22.8	23.0	22.5
November	21.5	21.4	21.3	21.3	21.1	21.2	22.5	22.7	20.4	21.9	21.7	21.5
December	19.4	19.3	19.1	19.1	19.0	19.5	21.2	20.5	20.1	19.9	19.8	19.8

Table 15. PROGRAMME OF WORK (AGRONOMY) FOR 1974

Project No	Name of the Project	Venue
Agr. I (231)	Nutritional requirement of coconut under different soil types	Kasaragod
Agr. II (231)	Irrigation and drainage problems : water requirement of coconut palm	Kasaragod
Agr. III (231)	Cultural cum spacing trial	Kidu and Kasaragod
Agr. IV (231)	Inter and mixed cropping trials with annual and perennial crops	Kasaragod and Nileswar
Agr. V (231)	Nursery studies : standardisation of selection criteria	Kasaragod
Agr. VI (231)	Maintenance of cost of production	Kasaragod
Agr. VII (231)	Agrostology : Mixed farming in coconut gardens by raising fodder grass and maintaining milch cows	Kayangulam and Kasaragod
Agr. VIII (231)	Microclimate studies in relation to growth and disease incidence	Kayangulam and Kasaragod
All India Co-ordinated Project		
Experiment 7	NPK fertilizer experiment on major soil types in different agroclimatic regions on ordinary Tall variety	Veppankulam, Mahua, Pilicode, Neyyattinkara, Ratnagiri, Ambajipeta, Andamans and Kasaragod
Experiment 8	Nutritional requirements of high yielding coconut varieties and hybrids	Vittal
Experiment 9	Spacing cum method of planting experiment on the ordinary Tall variety of coconut	Mahua and Kidu
Experiment 10	Intercultivation *Vs* weed control by herbicides in adult bearing plantations	Veppankulam and Mahua

Experiment 11	Inter and mixed cropping trials	Veppankulam
Experiment 12	Efficiency of different soil conservation measures	Veppankulam and Kasaragod
Experiment 13	Fertilizer and water requirement of palms being utilised for tapping	Veppankulam, Pilicode, and Kasaragod
Experiment 14	Effect of sea water irrigation on soil and yield of palms	Kasaragod
Experiment 15	Irrigation cum fertilizer experiment	Veppankulam and Mahua

SUMMARY

In the field experiment to evaluate the comparative efficacy of different sources of phosphatic fertilizers in a laterite soil, available P status of the soil was the highest for superphosphate followed by nitrophosphate, ammonium phosphate, and powdered (200 mesh) rock phosphate. The leaf nutrient status did not show any difference in the different treatments. In sandy soil the seedlings receiving cattle manure maintained better growth as compared to those receiving other organic sources of manures. In a sandy loam soil, application of high levels of NPK fertilizers resulted in lowering the soil pH, increasing the availability of Mn, Fe, and Al, and increasing the uptake of Mn, Zn, and Cu. Foliar yellowing and rubbery kernel in coconut were found to be generally associated with low levels of Mg and S in soil and imbalance of nutrient cations in the leaves. Fe, Mn, and Zn were low in both soil and leaf samples collected from root (wilt) affected areas.

Work in progress

SCh. I (231). **Phosphorus nutrition of coconut palm**

(M. P. Sankaranarayanan, P. Abdul Wahid, C. B. Kamala Devi, and Nursery Asst., (Vittal)

The field experiment started in 1971 was continued to evaluate the comparative efficacy of different sources of phosphatic fertilizers in a laterite soil. Analyses of soil and tissue samples showed that (1) available P in soil was the highest with superphosphate at second and third levels of P (640 and 960 g P_2O_5 per palm per year with 62.2 ppm and 62.8 ppm, respectively), followed by nitrophosphate, ammonium phosphate and powdered rock phosphate (200 mesh); (2) available K was maximum (787 ppm) for nitrophosphate at the highest level of P and; (3) there was no significant difference in nutrient status of leaf tissues due to the treatments. Out of the 299 experimental palms, only 87 had flowered of which 57 commenced bearing. The experiment is being continued.

SCh. II (231). **Studies on the micronutrient status of coconut soils and tissues: depletion of micronutrients due to higher levels of NPK fertilizer application**

(C. B. Kamala Devi and P. Abdul Wahid)

An NPK fertilizer experiment has been in progress in a sandy loam soil since 1965 using three high yielding genotypes, *viz.*, high yielding Tall, Tall x Dwarf, and Dwarf x Tall and at three levels of fertilizers (M_0 – no fertilizer, M_1 – 500 g N, 500 g P_2O_5, and 1000 g K_2O; and M_2 – 1000 g N, 1000 g P_2O_5, and 2000 g K_2O). The water soluble and exchangeable Fe and Al status of the soil were significantly increased and the reducible Mn fractions were decreased in the fertilized plots. Foliar levels of Mn, Cu, and Zn of the palms receiving fertilizers were also significantly higher. The genotypes did not vary significantly in the different treatments (Table 16).

SCh. III (231). **Study of organic matter status of soil under different manurial practices**

(C. K. B. Nambiar and Res. Asst., (Kasaragod)

Seedlings receiving cattle manure, forest leaves, and coconut sheddings had significantly more girth at collar (50.4, 45.7 and 36.2 cm respectively) than that of control (26.5 cm). There was significant build up of organic carbon in treated plot (0.081%-0.089%) as compared to control (0.036%). The experiment is being continued.

Table 16. TRACE ELEMENT STATUS OF LEAF AND SOIL UNDER DIFFERENT FERTILIZER LEVELS (MEAN VALUE IN PPM)

	pH	TRACE ELEMENT STATUS OF SOIL								TRACE ELEMENT STATUS OF LEAF					
		Exch-angeable Fe	Mn			EDTA extractable Cu	Dithi zone extractable Zn	Amm. Oxalate extractable Mo	Kcl extractable Al	Fe	Mn	Cu	Zn	Mo	Al
			Water soluble	Exchangeable	Reducible										
Genotype															
High yielding Tall	4.6	1.97	7.28	12.84	116.78	1.27	2.91	0.021	45.44	309.00	678.00	17.40	24.60	0.80	4.44
Tall × Dwarf	4.5	1.78	8.85	12 08	120.57	0.49	3.16	0.019	45.89	281.00	670.00	20.40	26.30	0.75	4.89
Dwarf × Tall	4.5	1.55	7.60	10.36	111.92	0.70	2.85	0.020	46.61	261.00	685.00	16.80	23.80	0.74	4.61
Fertilizers															
M_0	5.1	1.43	0.36	7.48	143.78	0.99	2.97	0.019	34.44	276.00	426.00	11.50	132.0	0.75	4.56
M_1	4 3	1.63	8.93	14.04	108.71	0.68	3.13	0.021	46.94	277.00	765.00	20.30	29.00	0.67	4.11
M_2	4.2	2.23	14.44	13.76	96.78	0.79	2.81	0.020	56.56	297.00	842 00	22.80	32.50	0.87	5.28
General mean	4.56	1.77	7.91	11.76	116.42	0.82	2.97	0.020	45.98	283.00	677.00	18.20	24.90	0.76	4.65
S. E. per plot	0.10	0.52	4.01	2.82	10.31	1.06	1.18	0.008	3.25	40.46	100.28	9.25	5.75	0.34	2.74
F ratio (fertilizer)	377.50	5.68	28.24***	15.54***	50.57***	1	1	1	104.78***	1	43.84	3.77*	28.61***	1	0.42
CD (5% level)	0.06	0.52	4.00	2.82	10.30	—	—	—	3.25	—	100.20	9.24	57.5	—	—

SCh. IV (231). **Studies on calcium, magnesium, and sulphur status of soils and tissues in relation to foliar yellowing and rubbery kernel of nuts**

(N. G. Pillai, P. L. Ramanandan, P. G. Kamalakshy Amma, P. Abdul Wahid, and C. B. Kamala Devi)

Representative soil and leaf samples from healthy areas and areas showing foliar yellowing and rubbery kernel were analysed for Ca, Mg, and S. The mean values showed that exchangeable Mg was low in sandy loam (0.69 me/100 g), reclaimed clayey, (1.24 me/100 g) and alluvial soils (1.18 me/100 g) of the affected tract as compared to perfectly healthy tract with the same soil types (0.83, 1.69, and 1.80 me/100 g, respectively). Available S status was low in all the soil types of the diseased tract (1.97 ppm *vs.* 13.47 ppm in sandy loam; 3.90 *vs.* 4.18 ppm in coastal sandy; 94.08 ppm *vs.* 124.24 ppm in reclaimed clayey; 15.5 ppm *vs.* 82.08 ppm in alluvial; and 25.62 ppm *vs.* 32.77 ppm in laterite), but the tissues did not show any differences. No consistent variation was observed for Ca content. The K/Mg ratio in leaf tissues, was higher in palms of the affected area (0.78–1.14 *vs.* 0.71 in healthy). A similar trend was obtained for the K/Ca ratio also (1.37–1.99 in the diseased and 1.30 in healthy) indicating imbalance in nutrient cations. Analysis of copra samples has now been taken up.

All India Co-ordinated Project

Fe, Mn, S, and Zn were found to be present in lower quantities in both the soil and leaf tissue samples collected from the root (wilt) affected tracts as compared to those from healthy. The K content of leaf was higher in the disease affected tract while Na and Mg were lower.

Table 17. PROGRAMME OF WORK (SOIL CHEMISTRY) FOR 1974

Project No.	Name of the Project	Venue
Sch. I (231)	Phosphorus nutrition of coconut palm	Vittal and Kasaragod
Sch. II (231)	Studies on micronutrient status of coconut soils and tissues	Kasaragod
Sch. III (231)	Study of organic matter status of soil with different manurial practices	Kasaragod
Sch. IV (231)	Studies on calcium, magnesium, and sulphur status of soils and tissues in relation to foliar yellowing and rubbery kernel of nuts	Kasaragod and Kayangulam
All India Co-ordinated Project		
Experiment 16	NPK fertilizer experiment on root (wilt) affected palms	Kayangulam
Experiment 18	Analysis of soil and tissue samples collected from healthy and root (wilt) and yellow leaf affected tracts	Kasaragod

PLANT PHYSIOLOGY

SUMMARY

A high carbohydrate reserve and C/N ratio in the stem have been found to precede the commencement of bearing in the palms of WCT variety. Rate of apparent photosynthesis in the adult palm of the WCT variety is significantly correlated with total chlorophyll content, annual yield of nuts, and the number of leaves on the crown.

A preliminary study of the amino acid spectrum of different coconut varieties revealed the presence of an additional amino acid in the TxD hybrids.

Work in progress

Phy. I (231). Reducing prebearing age of coconut palm

(A. Ramadasan, Chacko Mathew, and R. V. Pillai)

1. Role of carbohydrate reserves

A study was conducted, to determine the role, if any, of the carbohydrate reserve in the stem on the commencement of flowering using a batch of 18, eight year old WCT palms belonging to two groups, those that had commenced bearing, and those that had not commenced bearing. The total carbohydrate and N contents in the stem and leaves were estimated. The number of leaves produced so far and the number of leaves present in the crown were also recorded. (Table 18). The carbohydrate content in the stem of the palms in the first lot was significantly higher than those in the second group while the reverse was the case with N content. Consequently the C/N ratio was also significantly high in the stem tissue of bearing palms. The number of leaves produced so far and the number of leaves present were also significantly higher in this lot. The carbohydrate content of the stem over that in the leaves was 107% more in the bearing palms while it was only 37% in the nonbearing palms. These results suggest that a high carbohydrate reserve in the stem and a high C/N ratio are necessary prerequisites for commencement of flowering.

2. Effect of growth regulators

Preliminary observations from field study to investigate the effect of different concentrations of GA_3 on seedlings revealed that treatments with 500 ppm and 1000 ppm concentrations produced elongation and enlargement of two youngest leaves. The study is being continued.

Phy. III (231). Physiological derangements in coconut caused by root (wilt) disease

(K. J. Michael, A. Ramadasan, and B. Sumathykutty Amma)

No appreciable differences in the metabolism of nutrient elements has been noted so far in artificially inoculated young palms.

The optimum conditions to measure the respiratory rate in coconut leaf using the Warburg apparatus were standardised. The youngest fully opened leaf was found to be the most representative one. Fifteen leaf discs of six mm diameter and 30 C temperature in the water bath were optimum for the study.

Phy. IV (231). Physiology of foliar yellowing

(Thomas Varkey and Chacko Mathew)

The object of this study, initiated this year is to investigate the physiological factors associated with the seasonal foliar yellowing. The programme

Table 18. Production of leaves, carbohydrate content, and C/N ratio in the stem in relation to commencement of bearing

Characters		Palms that have commenced bearing	Palms that have not commenced bearing	Difference
Total number of leaves produced	Mean	72.00	60.00	12.00**
	SD	8.90	6.31	
Total number of leaves present	Mean	21.00	17.50	3.50**
	SD	2.45	2.17	
Total carbohydrate content in leaves (mg/100 mg dry wt.)	Mean	6.30	6.99	0.69
	SD	1.59	1.40	
Total carbohydrate content in stem (mg/100 mg dry wt.)	Mean	13.05	9.60	3.45**
	SD	1.43	1.82	
Total nitrogen content in stem (mg/1 g dry wt.)	Mean	12.63	15.11	2.48**
	SD	1.83	2.21	
C/N ratio in stem	Mean	1.05	0.64	0.41**
	SD	0.14	0.11	

* Significant at P = 0.05 ** Significant at P = 0.01

of work includes analysis of N, P, K, Ca, Mg, Fe, Mn, and chlorophyll fractions every month in the leaf tissue, drawn from four groups of palms, *viz.*, (1) palms of healthy tract showing yellowing; (2) palms of healthy tract not showing yellowing; (3) palms of root (wilt) diseased tract showing yellowing; and (4) palms of diseased tract not showing yellowing. The study is in progress.

Phy. V (231). Physiology of disease resistance

(B. Sumathykutty Amma and K. V. Joseph)

The object of this study, which was begun this year, is to investigate the physiological factors of resistance to root (wilt) disease in the TxD and DxT palms showing different degrees of tolerance to the disease. The programme of work includes analysis of phenol fractions and amino acids. The analysis of a few leaf samples of these hybrids and of WCT palms revealed the presence of an additional amino acid in the TxD palms. It has been tentatively identified as pipicolic acid.

All India Co-ordinated Project

A manometric method of determining the rate of apparent photosynthesis in adult palms was standardised. The rate of apparent photosynthesis and chlorophyll content were determined in 100 WCT palms. The rate of photosynthesis is significantly correlated with annual yield of nuts, the chlorophyll content, and number of leaves in the crown.

In another study on the photosynthetic efficiency of one year old seedlings, the NAR (net assimilation ratio) was found to be significantly correlated with girth at collar, total chlorophyll content, the number of leaves, and chlorophyll a/b ratio. The study is being continued.

Table 19. PROGRAMME OF WORK (PLANT PHYSIOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Phy. I (231)	Reducing prebearing age of coconut palm	Kasaragod
Phy. III (231)	Physiological derangements in coconut palm affected by root (wilt) disease	Kayangulam
Phy. IV (231)	Physiology of foliar yellowing	Kayangulam and Kasaragod
Phy. V (231)	Physiology of disease resistance	Kayangulam
Phy. VIII (231)	Photosynthetic efficiency in relation to yield	Kasaragod

BIOCHEMISTRY

Table 20. PROGRAMME OF WORK (BIOCHEMISTRY) FOR 1974

Project No.	Name of the Project	Venue
All India Co-ordinated Project		
Experiment 38	Biosynthesis of proteins, lipids and carbohydrates and quality of end products in various varieties of coconut and arecanut	Kasaragod
Experiment 39	Protein and carbohydrate metabolism in relation to root (wilt) disease of coconut and yellow leaf of arecanut	Kayangulam
Experiment 40	Biochemical aspects of host-parasite interactions in relation to root (wilt) and leaf rot disease of coconut	Kayangulam

TECHNOLOGY

Deodorisation and preservation of coconut toddy

(V. P. Potti, V. Hariharasubramanian, N P. Jayasankar, K. V. Joseph, and K. Sethumadhava Menon)

Collaboration: **Central Food Technological Research Institute, Mysore**

A process was developed to deodorise coconut toddy and preserve it. A pilot plant has also been designed for this. With this plant, it would be possible to pastureise approximately 500 *l* toddy in eight hours.

Table 21. PROGRAMME OF WORK (TECHNOLOGY) FOR 1974

Project No.	Name of the Project	Venue
All India Co-ordinated Project		
Experiment 43	Designing of copra driers	Mysore
Experiment 44	Manufacture of desiccated coconut after partial removal of oil	Mysore

MICROBIOLOGY

SUMMARY

The levels of polyphenol oxidase and peroxidase were significantly higher in the roots of infected palms as compared to those of healthy palms.

Work in progress

Micro. I (231). **Rhizosphere microflora in relation to root (wilt) disease and microbial interactions**

(V. P. Potti and N. P. Jayasankar)

The quantitative and qualitative distribution of microflora in the rhizosphere soils of coconut palms cultivated on either sides of the line demarcating the spread of the root (wilt) disease is in progress. Isolation and characterization of bacteria as pure cultures from intact roots of diseased coconut palms necessitated development of assay techniques based on diagnostic measures for proper screening. The polyphenol content of coconut roots decreased with the incidence of the disease, which may be attributed to its possible oxidation to more toxic products. Similarly, there was an increase in the levels of polyphenol oxidase and peroxidase activities in the roots of coconut palms with the incidence of root (wilt) disease. The levels of these enzymes in the apparently healthy palms in the diseased tract and the diseased palms were significantly different. In another study, a factor suspected to be phenolic was found to be constantly present in the leaves of coconut palms of Kasaragod (healthy area) and it was absent in the leaves of those cultivated at Kayangulam (diseased area).

A field experiment was laid out to assess the effect of Ca and Mg on the infectivity of *Rhizoctonia solani* in inducing root damage, with reference to the root (wilt) disease.

Table 22. PROGRAMME OF WORK (MICROBIOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Micro. I (231)	1. Enumeration of bacteria, actinomycetes, and fungi and their identity	Kayangulam
	2. Studies on the influence of mixed cropping on the rhizosphere microflora in relation to the incidence of root (wilt) disease	Kayangulam
	3. Effect of variation on the rhizosphere microflora in relation to the incidence of root (wilt) disease	
Micro. II (231)	1. Studies on the mechanism of vascular browning and decay of roots and its control	Kayangulam and Kasaragod
	2. Screening of microbial isolates found associated with the disease, for toxins	Kayangulam and Kasaragod
All India Co-ordinated Project		
Experiment 19	1. Isolation and identification of dominant bacteria from diseased coconut palms	Kayangulam and Kasaragod
	2. Screening of the isolates for tissue disintegrating enzymes and toxins	Kayangulam

PLANT PATHOLOGY

SUMMARY

Villages of Tamil Nadu bordering Kerala, in Ramnad, Madurai, and Coimbatore districts were found to be free of root (wilt) disease. Studies on symptomatology of the disease showed that internal disorganization of roots occur also in T x D and D x T palms. Four year old WCT seedlings planted in concrete tubs containing soil from healthy area (Peechi) and mixed with roots of diseased trees developed flaccidity of leaflets comparable to that of root (wilt) disease. No positive results were obtained when five purified samples of diseased coconut were tested against the TMV (coconut) isolate antiserum. To study the extent of seed transmission of the disease, controlled pollination was done to get nuts from healthy and diseased palms crossed with diseased pollen. Symptom expression on *Physalis minima*, produced by addition of root soakates of diseased palms, was seen to be favoured by a humid atmosphere. In the field experiment started in 1970 to study the role of nutrients on incidence of disease showed that seedlings under Mg_0 treatment developed foliar yellowing. One seedling each from $N_0P_1K_0Ca_0$ Mg_0 and $N_1P_2K_2$ Ca_1 Mg_0 treatments developed symptoms of root (wilt) disease. An unidentified fungus having white mycelium and clamp connections was isolated from the bark and root of the stem bleeding affected trees. The fungus was found in some of the healthy samples also. Inoculation of bacteria on *Phytophthora palmivora* infected tissues hastened further rotting and secondary infections. Oospores of *P. palmivora* survived for 11–17 months in infected plant tissue and in agar culture mixed with steamed soil.

Work in progress

Path. 1.1 (231). Studies on spread of root (wilt) and leaf rot diseases

(N. Gopinathan Pillai and K. J. Thommen)

Villages of Tamil Nadu bordering Kerala, in Ramnad, Madurai, and Coimbatore (Pollachi taluk alone) districts and Achancoil area of Kerala were surveyed for the presence of root (wilt) and leaf rot diseases. Except for Achancoil, all the other surveyed areas were free of the diseases. In Kanyakumari district (Tamil Nadu) a few gardens in Ponmanai village, near Kulasekharam, were found to be affected by both the diseases. Intensity of disease of individual palms was assessed by indexing.

Half yearly observations made to assess the rate and pattern of spread of the disease in the border areas showed that it has spread into the experimental plot at Nemum in Trivandrum district.

Path. 1.2 (231). Symptomatology of root (wilt) disease

(K. Radha, V. P. Potti, and M. V. George)

1. Histopathogenic studies

Apparently healthy roots of healthy palms, 414 samples of TxD, and 119 samples of DxT hybrids growing in the disease affected gardens were studied. The samples were collected from a one-eighth sector of the bole within 90 cm radius, 10-12 samples per plant. Out of 414 samples 16 from seven TxD seedlings and 29 root samples (out of 119 samples) from eleven DxT seedlings showed internal discolouration and disorganization of tissues upto 2.5-3.8 cm of the tip.

2. Sequence of development of symptoms

Twelve out of the 49 experimental seedlings exhibited flaccidity and yellowing while four were also affected by marginal necrosis of leaflets.

3. Indexing for disease severity

Work completed and data published.

Path. 1.3 (231). Etiology of the root (wilt) disease

(Joint Director, (Kayangulam), K. Mathen, V.G. Lilly, Thomas Varkey, and A. S. Mathew)

1. Pathogenicity trials

Crude leaf extract of diseased palms was inoculated at monthly intervals on tender leaves of 13 experimental seedlings and 20 young palms at Kannara substation.

Root sap collected from diseased palms was injected at quarterly intervals on stem of experimental young palms at Kannara till April and discontinued afterwards since it was felt that the total of 23 leaf inoculations and three stem injections given, so far, would suffice to transfer the pathogen, if any. Disease symptoms had not appeared during the period of this report either in the seedlings or in the young palms. Analysis of soil and leaf samples' collected during November 1970 (pre treatment) and December, 1971 (post-treatment) were completed and fresh samples for post treatments were collected in April.

Five potted seedlings grown at Kayangulam and six at Peechi using Peechi soil incorporated with diseased roots were transplanted in February to bigger reinforced cement concrete tubs. In September flaccidity of leaflets comparable to that of root (wilt) disease was observed in 4/5 seedlings at Kayangulam and 1/6 at Peechi. Of the remaining, one at Kayangulam and 3/5 at Peechi also showed suspected symptoms. Disease index scores showed that the disease was intensifying in both the centres. The intensity was lower at Peechi.

2. Soil conditions as predisposing factors

The exchangeable Ca and Mg content in the soil of diseased and healthy coconut gardens in the northern border was completed for the samples collected during 1972, a fresh set of soil samples was collected during the year and they are being analysed. So far, no appreciable difference between healthy and diseased tracts have been observed for Ca and Mg.

3. Studies on associated fungi

A pure culture of possibly *Rhizoctonia solani* originally isolated from coconut was sent to Commonwealth Mycological Institute, London, for confirmation of identification. *In vitro* studies were in progress for pectinolytic enzymes.

Path. 1.4 (231). **Diagnosis of root (wilt) disease**

(Asst. Virus Pathologist, (Kayangulam), M. Sasikala, Junior Biochemist, (Kayangulam), P. G. Kamalakshy Amma, and A. Ramadasan)

1. Serology

Attempts were under way to prepare an antiserum against the flexuous rods isolated from diseased coconut. When five purified samples of diseased coconut were tested against TMV (coconut) antiserum, no positive reaction was noticed indicating the absence of this strain of TMV in the samples tested.

2. Host range

Nearly 1300 plants of 49 species belonging to 11 families were mechanically inoculated with crude as well as purified extracts of different tissues of diseased coconuts. Less than one per cent samples tested gave positive transmission on *Physalis minima* but it was a strain of TMV. Since the percentage of infected samples was very low, it was concluded that this virus was not related to root (wilt) disease.

Soil transmission trials were done with nearly 400 plants of 40 species belonging to four families. Positive reactions were obtained on *Nicotiana tabacum* var. S. 20 (in 3/11 tested). Positive results were also obtained from tissue implantation of coconut roots (in 2/3 tested) on to *Nicotiana tabacum* vars. Havana and S. 20. Further studies are in progress to identify the pathogen involved.

Path. 1.5 (231). Studies on transmission of root (wilt) disease

(V. G. Lilly, K. Mathen, and M. Sasikala)

1. Seed transmission

This study was modified to include controlled pollinated nuts of diseased x healthy palm, diseased x diseased palm of root (wilt) affected area (Kayangulam), healthy x diseased palm and healthy x healthy palm of healthy area (Kannara). The nuts are due for harvest in March, 1974.

Thirty WCT seedlings raised from open pollinated nuts of palms of diseased area were planted at Kannara (healthy area) along with 30 WCT healthy seedlings from Kasaragod.

2. Role of lower fungi

One hundred and ten roots of 25 palms of healthy tract and 230 roots of 30 palms of diseased tract were examined. A chytridiaceous fungus, tentatively identified as *Olpidiopsis*, was observed in all the samples examined. This was observed in stems and leaves also. An unidentified phycomycetous fungus was also isolated from vascular tissues of roots on a special nutrient medium and the culture has been sent for identification. The experiment would be repeated under insect proof conditions during the rainy season.

One hundred roots were screened for the rhizoplane fungus on 100 roots. Microphotographs of the fungus were sent to Dr. J. L. Harby, Oxford, for identification.

Path. 1.6 (231). Studies on control of root (wilt) and leaf rot diseases

(S. Robert Cecil, K. Radha, P. L. Ramanandan, R. V. Pillai, and P. G. Kamalakshy Amma)

1. Role of nutrients in the control of diseases

This experiment was started in 1970 to study the role of three levels of N, P, and K, and two levels of Ca and Mg in the control of diseases. Fertilizers were applied as per schedule. Addition of Ca and Mg to NPK fertilizers gave superior growth than when NPK was alone applied. Between Ca and Mg, Mg gave better growth. Seedlings under Mg_0 treatments have, in general, developed foliar yellowing. Two seedlings (one from $N_1P_2K_2$ Ca_1 Mg_0 and the other from $N_0P_1K_0$ Ca_0 Mg_0) have developed symptoms of root (wilt) disease. All the seedlings were indexed for the disease symptoms. Representative leaf samples were collected for analysis.

2. Nutritional requirements of D x T palms in root (wilt) affected area

This experiment, started in 1972, is in progress.

3. Varietal resistance studies

In addition to the two field experiments started last year, a new one has been laid out at Kayangulam with 16 cultivars/hybrids. These included Andaman Giant, Andaman Ordinary, British Solomon Islands, Cochin China, FMS, Jamaica, Philippines, S. S. Apricot, S. S. Green, Tall x Malayan Dwarf, San Ramon x Gangabondam, Fiji x Gangabondam, Java x Gangabondam, Laccadive x San Ramon, Fiji x S. S. Green, and West Coast Tall.

Path. II (231). Studies on the stem bleeding disease

(P. L. Ramanandan, Thomas Joseph, A. S. Mathew, Res. Asst., (Kasaragod), and B. Sumathykutty Amma)

Samples of soil, root, bark, and leaf were collected for analysis from Goa (five sites), Tamil Nadu (six sites), Karnataka (two sites) and Kerala (four sites). Sixteen trees out of 25 diseased experimental palms in Tamil Nadu, one out of five in Chitradurga (Karnataka), and one out of 25 in Goa died during the year.

The fungus *Ganoderma* sp. so far suspected to be responsible for the disease was sent for identification to the CMI, Kew. They were unable to identify it and described it as having white mycelium and clamp connections. This fungus had been isolated from 6/144 healthy and 6/147 diseased bark samples, and 13/138 healthy and 22/143 diseased root samples collected from the different experimental plots. Besides, from among the bark and root samples of five healthy palms of Tirunelveli (Tamil Nadu) one bark and one

root had the same fungus. Other isolates were the usual non-pathogenic fungi like *Diplodia* and *Trichoderma*. Analysis of the soil samples was completed. Root and leaf analyses are in progress.

Path. III (231). Investigations on the bud rot disease

(K. Radha and Thomas Joseph)

A. P. Cess Fund Scheme

1. Comparative infectivity of *Phytophthora palmivora* and bacteria

Infectivity of *P. Palmivora*, *Xanthomonas*, and *Erwinia* (isolated from the crown of a bud rot affected palm) was tested under controlled conditions. Tender petiole pieces of coconut were inoculated with the test organisms and incubated at 24°C under high humidity. The inoculations were done both individually and in combinations. In the latter case, *P. palmivora* inoculation was given before that of the bacteria. When the inoculations were done individually, the fungus infected the intact tissues while the bacteria failed to do so. However, when superimposed on *P. palmivora* lesions, the bacteria hastened secondary infection and rotting of tissues.

2. Studies on the survival of pathogen

Survival of *P. palmivora* was studied in infected material and in soil using (1) culture of the pathogen in synthetic agar containing live sporangia and oospores mixed with steamed soil; (2) culture of the pathogen in agar media which produced oospores on contamination with *Thielaviopsis* sp., and (3) coconut petioles artificially infected with *P. palmivora* and producing oospores. They were incubated at 22–24°C. Oospores of *P. palmivora* remained viable for 11 months on coconut petioles and in agar culture contaminated with *Thielaviopsis* sp. while in agar culture mixed in soil it remained viable for 17 months.

Path. IV (231). Estimation of crop losses due to diseases

(M. V. George, K. J. Thommen, and Jacob Mathew)

The second round of survey was completed six months after the first round in all the 25 selected villages in Quilon district. In this, 6,536 palms from 99 selected gardens were examined for disease incidence and pest infestation and grouped into various categories according to the intensity of disease incidence. The foliar conditions and total yield in all the bunches which are five months and more in maturity were recorded twice at six monthly interval from about 1400 palms under various categories.

Out of the 6,536 palms observed, 16.1% were healthy, 53.9% *Oryctes* infested, 21.0% diseased early and 9.0% diseased advanced. Data on yield, are presented in the Table 23.

Table 28. Average yield and reduction in yield of nuts at varying intensities of the root (wilt) disease

	Healthy	Diseased early	Diseased advanced
No. of palms examined	1054	1372	590
Percentage of total palms	16.1	21.0	9.0
Average yield of nuts/palm	38.8	26.6	11.1
Reduction of nuts over healthy	—	12.2	27.7
Percentage of reduction over healthy	—	31.5	71.5

According to the forecast report of the land utilisation survey, conducted by the Bureau of Economics and Statistics, Kerala State, Trivandrum, there are about 10.89 million bearing palms in Quilon district. Hence the loss in yield of nuts in palms in the early stages of disease works out to $10.89 \times 12.23 \times \frac{20.99}{100} = 27.95$ million nuts and the loss in yield in palms in the advance stages of disease as $10.89 \times 27.71 \times \frac{9.03}{100} = 27.25$ million nuts. Hence the overall loss due to root (wilt) and leaf rot is estimated as 55.20 million nuts.

All India Co-ordinated Project

Transmission trials using the indicator plant cowpea with lace bugs fed on diseased coconut leaf and liberated on varieties Pusa Phalguni and Pusa Dolsafi, were discontinued since the results were not conclusive. Flexuous rods seen under the electron microscope in healthy and diseased coconut root and leaf tissue extracts were found to be host proteins which break up into shorter particles of length comparable to that of TMV. Flexuous rods similar to tobacco etch virus were seen in *Physalis minima* with leaf crinkling. Diseased four year old coconut seedlings from the field were transplanted in pots after clipping off all roots and treating boles with tetracycline antibiotics and the systemic fungicides, methyl 1- (butyl carbamolyl) - 2 - benzimidazole carbamate (Benlate) and Kasumin.

Table 24. PROGRAMME OF WORK (PLANT PATHOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Path. 1.1 (231)	Studies on the spread of the root (wilt) and leaf rot diseases	Northern, Southern, and Eastern borders of wilt affected areas
Path. 1.2 (231)	Symptomatology of root (wilt) disease	Kayangulam and Kasaragod
Path. 1.3 (231)	Studies on etiology of root (wilt) disease	Kayangulam, Peechi, and border areas
Path. 1.4 (231)	Studies on diagnosis of root (wilt) disease	Kayangulam
Path. 1.5 (231)	Studies on transmission of root (wilt) disease	Kayangulam, Peechi, and healthy area (Kasaragod)
Path. 1.6 (231)	Studies on control of root (wilt) disease	Kayangulam
Path. II (231)	Studies on stem bleeding disease	Stem bleeding affected areas of Kerala, Karnataka, Tamil Nadu, and Goa
Path. III (231)	Investigations on the bud rot disease	Kayangulam
Path. IV (231)	Estimation of crop losses due to diseases	Kayangulam
All India Co-ordinated Project		
Experiment 20	Transmission trials on coconut seedlings using mechanical means and possible transmission agents	Kayangulam
Experiment 21	Electron Microscope studies	Kayangulam, Kasaragod, Trivandrum and New Delhi
Experiment 22	Culturing mycoplasma	Kayangulam
Experiment 24	Control of the root (wilt) disease by chemicals	Kayangulam

NEMATOLOGY

Soil and root samples, numbering 332 each and comprising of 251 from 74 root (wilt) affected localities and 81 from 19 completely healthy tracts in Kerala, were collected and processed. Stylet bearing nematodes belonging to 23 genera have been isolated and identified, of which, eight are new records. Population of *Radopholus similis* as high as 562 numbers/1 g soil have been recorded from roots of palms affected by coconut root (wilt). None of the samples from healthy areas yielded *R. similis*. However, a few root samples of WCT seedlings from the CPCRI, Kasaragod nursery were found to harbour *R. similis*. The burrowing nematode populations from banana and coconut at Kayangulam has been identified as the "banana race" attacking roots of coconut, arecanut, banana, sweet potato, sugarcane, and groundnut, but not *Citrus* spp. and black pepper.

Methyl bromide fumigation of pot mixture for raising pepper cuttings, has been recommended at the various government nurseries in Kerala for reducing root-knot infection.

Table 25. PROGRAMME OF WORK (NEMATOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Nema. I (231)	Investigations on plant parasitic nematodes associated with coconut	Kayangulam
Nema. I. 1 (231)	Survey	Kayangulam
Nema. I. 2 (231)	Standardisation of sampling zone	Kayangulam
Nema. I. 3 (231)	Virus transmission	Kayangulam
Nema. II (231)	Studies on *Radopholus similis*	Kayangulam
All India Co-ordinated Project		
Experiment 23	Studies on nematodes in relation to root (wilt) disease	Kayangulam

SUMMARY

Laboratory tests against grubs of *Oryctes rhinoceros* L. revealed that for immediate effect arprocarb was the most efficient insecticide and trichlorphon the least. Arprocarb and BHC had the highest residual effect. With regard to the deleterious effect of the insecticides on the beneficial predators like *Santalus parallelus* and *Agrypnus* sp., BHC caused maximum mortality and arprocarb least. Observations of palms in coconut gardens, where the exotic predator *Platymeris laevicollis* was liberated, showed a decrease in the incidence of the pest, and besides, dead beetles killed by the predator could be collected from the crown. The nematode DD-136 parasitized all the larval instars of *Oryctes*. BHC 0.2% and malathion 0.05% adversely affected the parasites of *Nephantis*. Studies on the fixation of 'norm' using *Bracon brevicornis* W. (double the number of pest) under caged conditions in the field gave a maximum of 57.6% parasitization. The exotic parasite *Spoggosia bezziana* B. was found to have established at all the three centres of liberation. Garlic oil suspension 0.125–1.0% caused 60–100% mortality of red palm weevil grubs in laboratory tests. Injection of trichlorphon 0.2% cured 46/50 red palm weevil infested palms. Under the sterile male release method for the control of red palm weevil, viability of eggs was 70.0% in the experimental area as compared to 95.7% in the natural population. Eriophyid mites were recorded for the first time from the coconut foliage. Feeding the chemosterilants colchicine 1.5 mg and furadantin 37.5 mg mixed with food prevented conception in female rats.

Work in progress

Ent. I (231). **Investigations on rhinoceros beetle, *Oryctes rhinoceros* L.**

(Asst. Entomologist, (Kayangulam), B. Sathiamma, Abdulla Koya, J. Antony, Elizabeth George, Mariamma Daniel, and Asst. Parasitologist, (Kayangulam)

1. Chemical control

i) Laboratory studies. (a) Insecticidal trials against grubs and adults of *Oryctes rhinoceros* L. and the predators *Santalus parallelus* and *Agrypnus* sp.

Comparative efficacy of insecticides was determined and the results are given below.

Table 26. Comparative efficacy of insecticides on the grubs of *Oryctes rhinoceros* L. — immediate toxicity — mean number of grubs killed

Treatments	Days after treatment		
	1	2	7
Control	0.0	0.0	0.0
BHC 0.01%	7.8	8.8	9.8
Carbaryl 0.01%	7.2	9.2	10.0
BHC + carbaryl 0.01%	6.0	10.0	10.0
Trichlorphon 0.0075%	3.6	4.8	8.4
Arprocarb 0.005%	9.4	10.0	10.0
S. E per plot	1.68	1.20	0.65
F ratio			
Control *vs.* insecticides	68.9**	231.1**	928.5**
Between insecticides	8.3**	23.4**	5.9**
C. D.	1.6	1.1	0.6

All the treatments were efficacious. Arprocarb was the most efficacious and trichlorphon the least.

Table 27. Comparative efficacy of insecticides on grubs of *O. rhinoceros* L. — residual toxicity — mean number of grubs killed

Treatments	Months after treatment					
	1	2	3	4	5	6
Control	0.2	0.0	0.0	0.0	0.0	0.2
BHC 0.01%	10.2	9.2	9.0	9.4	9.0	7.6
Carbaryl 0.01%	4.4	1.2	4.4	3.4	6.6	3.2
BHC + carbaryl 0.01%	8.6	7.2	7.4	8.0	7.4	7.4
Trichlorphon 0.0075%	5.6	2.4	4.4	4.0	5.0	3.2
Arprocarb 0.005%	10.0	8.8	10.00	9.2	9.4	7.6

S. E per plot	1.9839
F ratio	
Control *vs.* insecticides	285.1**
Between insecticides	51.8**
Months	4.4**
C. D. for insecticides	1.01

All the insecticides were significantly effective. However arprocarb and BHC were the most efficacious.

Table 28. Comparative efficacy of insecticides on the adults of *Santalus parallelus* immediate toxicity — mean number of predators killed

Treatments	Days after treatment		
	1	2	7
Control	0.0	0.0	0.0
BHC 0.01%	4.0	4.6	5.0
Carbaryl 0.01%	3.2	4.0	5.0
BHC + carbaryl 0.01%	3.8	5.0	5.0
Trichlorphon 0.0075%	3.6	4.2	5.0
Arprocarb 0.005%	2.4	2.4	5.0

S. E per plot	1.74	1.28
F ratio		
Control *vs.* insecticides	18.5**	48.4**
Between insecticides	.1	.5
C. D.	2.3	1.7

After seven days complete mortality of the predators was observed in all the treatments against nil in the control. No significant difference was observed between 1st, 2nd and 7th day after treatment.

Table 29. Comparative efficacy of insecticides on the adults of *S. parallelus* — residual toxicity — mean number of predators killed

Treatments	Months after treatment					
	1	2	3	4	5	6
Control	0.0	0.0	0.0	0.6	0.0	1.0
BHC 0.01%	5.0	5.0	5.0	4.0	5.0	4.8
Carbaryl 0.01%	3.8	3.4	4.0	2.4	3.4	3.8
BHC + carbaryl 0.01%	5.0	5.0	4.2	4.2	4.2	4.2
Trichlorphon 0.0075%	3.6	4.0	4.6	1.8	3.6	2.6
Arprocarb 0.005%	4.3	3.7	3.0	2.3	3.3	2.7

S. E per plot	1.279
F ratio	
Control *vs.* insecticides	201.2**
Between insecticides	8.6**
Months × insecticides	3.7**
C. D. for insecticides or months	0.65

All the insecticides caused death of the adults of *Santalus*. BHC alone or in combination with carbaryl caused maximum mortality.

Table 30. Comparative efficacy of insecticides on the grubs of *Agrypnus* sp. immediate toxicity — mean number of predators killed

Treatments	Days after treatment		
	1	2	7
Control	0.0	0.0	0.4
BHC 0.01%	1.8	3.0	3.0
Carbaryl 0.01%	2.0	2.6	3.0
BHC + carbaryl 0.01%	2.8	2.8	3.0
Trichlorphon 0.0075%	1.4	1.6	2.2
Arprocarb 0.005%	2.3	2.3	3.0
S. E per plot	1.033	0.735	0.603
F ratio			
Control *vs.* insecticides	16.08**	46.75**	66.50**
Between insecticides	1.37	2.72	1.72
C. D. between insecticides	1.4	1.0	0.8

All the insecticides were observed to be toxic one day after treatment. But no significant differences were observed among them.

Table 31. Comparative efficacy of insecticides on the grubs of *Agrypnus* sp. — residual toxicity — mean number of predators killed

Treatments	Months after treatment					
	1	2	3	4	5	6
Control	0.0	0.0	0.2	0.0	0.2	0.0
BHC 0.01%	3.0	2.6	2.8	3.0	2.2	2.8
Carbaryl 0.01%	1.4	2.4	1.2	2.2	1.8	1.4
BHC + carbaryl 0.01%	2.8	2.2	2.0	2.6	2.4	2.0
Trichlorphon 0.0075%	2.0	0.8	1.6	2.2	2.0	2.0
Arprocarb 0.005%	2.3	0.3	1.3	1.3	1.0	1.3

S. E per plot	0.809
F ratio	
Control *vs.* insecticides	145.05**
Between insecticides	12.42**
Between months	2.04
Months x insecticides	1.3
C. D. between insecticides	0.4

All the insecticides caused the death of the predators. They were significantly different in their efficacy, BHC causing the highest mortality and arprocarb the least.

Tests using these insecticides on the adults of *Oryctes rhinoceros* are in progress.

ii) Field studies. (a) Field control of rhinoceros beetle using 0.01% carbaryl: The 18th round of observations of 5% sample palms in November showed 11.81% leaf attack, nine fresh incidence and four spathe attack as against 32.18% leaf attack, 126 fresh incidence and 60 spathe attack under the pre treatment conditions.

(b) Maintenance of a permanent demonstration cum trial plot of rhinoceros beetle control using BHC 0.01% : Observations taken in August showed 13.6% leaf attack, 34 fresh incidence and no spathe attack as compared to 20.5% leaf attack, 96 fresh incidence and 17 spathe attack of the pre treatment conditions.

(c) Screening tests with chemical attractants: These experiments were carried out in cages set 50 m apart at the Regional Station farm, Kayangulam, with six treatments, *viz.*, (1) coconut log untreated, (2) coconut log treated with the solvent, (3) coconut log treated with the solvent + chemical, (4) cowdung untreated, (5) cowdung treated with the solvent, (6) cowdung treated with the solvent + chemical. The trials are in progress.

2. Biological control

i) *Parasites and predators.* (a) Field introduction and colonisation of *Platymeris laevicollis :* Insectory bred adults of the reduviid bug *P. laevicollis* (1850 nos) were liberated at Pandalam and Vittal. At Vittal, egg shells were collected from the crowns of palms and at Pandalam early stage nymphs were observed in the leaf axils of palms. Observations of palms at both the centres showed a decrease in the incidence of the pest and dead beetles killed by the predator were collected from the crown.

ii) *Pathogens.* (a) Trials using *Metarrhizium anisopliae* M & S: Field trials were carried out using combinations of the fungus and the insecticides, BHC and carbaryl 0.005%. Observations (after 15 days interval) revealed 100% mortality in all the treatments (90% only in carbaryl) against 20% in the untreated control.

(b) Trials using *Rhabdionvirus oryctes:* Bacteria isolated from the culture of *Rhabdionvirus* were mixed with bacteria-free inoculum of the virus and tried against *Oryctes* grubs for pathogenicity tests. Trials are in progress.

(c) The pathogenic bacteria, isolated from infected *Oryctes* grubs, earlier, were identified as *Serratia* sp. and *Pseudomonas* sp. (two isolates). These were tried against healthy grubs in all possible combinations. Mortality was observed on alternate days. Simultaneously, a 10^{-6} dilution of cowdung from each treatment was prepared and plated at different intervals, and counts of the particular bacteria were made five days after plating. The work is in progress.

Ent. II (231). **Investigations on the leaf eating caterpillar *Nephantis serinopa* M.**

(C. P. Ramachandran, K. N. Ponnamma, and Asst. Toxicologist, (Kayangulam)

1. Chemical control

i) *Bioassay of insecticides against parasites of Nephantis.* Bioassay of BHC was carried out against the eulophid, *Trichospilus pupivora* at its strengths varying from 0.00625 - 0.2%. Bioassay on elasmid and bethylid is in progress.

2. Biological control

During the report period, 1, 85, 840 braconids, 48, 230 bethylids 98, 760 elasmids, and 3, 23, 000 eulophids were bred for liberation and trials. For the control of *Nephantis* in the coconut plantation under the Kayangulam Kayal Reclamation Scheme, nearly 44, 800 eulophids, 24, 700 braconids, 2, 300 bethylids, and 1, 800 elasmids were supplied. A total of 3, 550 eulophids, 1, 270 braconids, 380 bethylids, and 330 elasmids were supplied to the Zonal Parasite Breeding Stations and Agricultural College, Vellayani (Kerala) and to the University of Agricultural Sciences, Bangalore.

3. Integrated control

Persistence of recommended doses of insecticides in the field and their effects on parasites. The first replication of the experiment was conducted at Purakkadu near Alleppey. Preliminary analysis of the data indicated that both BHC 0.2% and malathion 0.05% adversely affected the parasites. Leaf samples collected 24 hr after spraying showed the maximum mortality.

Ent. III (231). **Investigations on red palm weevil, *Rhynchophorus ferrugineus* F.**

(Asst. Toxicologist, (Kayangulam) K. M. Abdulla Koya, and Chandy Kurian)

1. Laboratory studies

i) *To assess the joint action of insecticides.* Nothing to report.

ii) *Trials using garlic oil.* The garlic oil (larvicidal principles: diallyl disulfide and diallyl trisulfide) was supplied by the BARC, Trombay. The grubs were introduced into cut pieces of petioles and allowed to establish. Garlic oil suspension in water was applied to the petiole at 0.125, 0.25, 0.5, 0.75 and 1.0% strengths. There were five replications with five grubs per replicate. Preliminary trials were also conducted against adults using the same method. The material was found to be effective only against the grubs. Further trials are in progress.

2. Field studies

Trichlorphon 0.2% was injected into 50 infested palms (including 37 palms of the earlier trials) in which the pest entry was through the stems. Of these 46 palms survived.

3. Integrated control

Maintenance of a garden free of infestation by adopting all proved methods of weevil control. Scheduled treatments were continued during the period. As a prophylactic measure against weevil entry, 132 palms affected by leaf rot/bud rot (which usually offer ideal sites for oviposition by the weevil) were cured of the infection by treating the palms with bordeaux mixture/paste and with BHC.

Only 13 cases of weevil infestation were observed during the year, as against 69 in 1970, 43 in 1971, and 14 in 1972. About 10% of the experimental palms were infected by root (wilt) disease.

Ent. V (231). **Studies on minor pests of coconut**

(B. Sathiamma)

1. Mites

i) *Collection, isolation, and taxonomy studies.* Mites were isolated from 324 soil (from the bole of the palm), 10 soil + litter, 50 leaf, 25 inflorescence and 50 root samples collected during the year. Those associated with the foliage were found to belong to the families Tetranychidae, Tenuipalpidae, Eriophyidae, Galumnidae, Phytosiidae, Cheyletidae, and Liroaspidae; and those

from soil, soil + litter, and root samples to Orbatidae, Ascaidae, Circocyllibanidae and Pseudocheylidae. Mites associated with red palm weevil and rhinoceros beetle belonged to the families Uropodidae, Fedrizzidae, Macrocheylidae, Circocyllibanidae, and Zerconidae.

ii) *Biology of phytophagous and predaceous mites and the coccinellid predator Stethorus keralicus.* Observations on the biology of the coconut white mite (tetranychid) showed that the total life cycle under laboratory conditions ranged from 21–23 days with an incubation period of 4 days, larval 3–4 days, protonymphal 3 days, deutonymphal 4 days, and adult 7–8 days.

iii) *Population counts of mites on apparently healthy and diseased palms.* Twelve palms each of apparently healthy, early diseased, and advanced diseased were selected and soil, root, foliage, and inflorescence samples collected at monthly intervals, to study the seasonal abundance, comparative abundance of mites in relation to healthy and diseased, and mite fauna at various distances and depths from the bole of the palm.

An important observation made was the presence of eriophyid mites from the coconut foliage because many of the proved vectors of plant viruses belong to the superfamily Eriophyoidea. Their role, if any, in relation to the coconut root (wilt) disease has to be investigated.

All India Co-ordinated Project

The experiment on sterile male release method for the control of red palm weevil was in progress at Vavvakkavu (Quilon district). Pest infested palms (272 nos.) were treated with Pyrocon-E/Carbaryl to bring down pest population. Sterilized males (5,338) received from BARC, Trombay, were liberated at the centre of the experimental area. Traps were set up and 275 weevils were collected which consisted of 88 females and 187 males (64 sterilized and 123 from the natural population). From the 88 females, 640 eggs were collected of which 448 eggs hatched, thus, its viability was 70.0%. Under natural conditions, the viability of eggs was 95.7%. This decrease in the viability of eggs, laid by females captured from the experimental centre, could be the result of sterile male release.

Control of rats using zinc phosphide was continued in the campus at Kayangulam. A total of 17,595 baits were placed and nearly 85% were lifted. In Block I, where rat control operations are in progress, the incidence of rats was brought down from 34 to zero within six months and the loss of nuts from six to zero. Female rats fed with the chemosterilant (a mixture of 1 mg colchicine and 25 mg furadantin) in 10 g of grated coconut kernel conceived. Enhanced doses, colchicine 1.5 mg and furadantin 37.5 mg, were effective in preventing conception.

The new coreid bug was found in pockets of infestation at Kozhikode, Ernakulam, Alleppey and Quilon districts of Kerala. Field observations of

palms in CPCRI campus revealed 0.38%, 0.39%, 0.06% and 0.21% infestation by this pest during the four quarters of the year. In a heavily infested area at Pullad (Alleppey district) 70%, 70% and 66% incidence were noticed in three adjacent gardens. The pest was identified as *Paradasynus* sp. The borers *Xyleborus* sp. and *Diocalandra stigmaticollis* were observed on diseased palms at Utchipuli (Ramnad district, Tamil Nadu).

Trials for fixing 'norms' on the release of laboratory bred indigenous parasites for the effective control of *N. serinopa* M. under caged conditions in the field were initiated. Two trials, with the norm as double the number of pests and replicated thrice, were completed. A maximum of 57.6% parasitization with *Bracon brevicornis* was noted. The third trial is in progress.

A good stock of culture has been built up with the six consignments of nearly 360 puparia of *Spoggosia bezziana* Bar., obtained from the CIBC, Bangalore. *Corcyra cephalonica* was recorded as an alternate host for *S. bezziana*. Follow up studies made at the three centres of liberation revealed its establishment in the field.

Laboratory trials with the nematode DD-136 against the three instars of *Oryctes* grubs, when mixed with the feed of the grubs (cattle dung), proved that all the three instars were liable to nematode infection, causing 100% mortality to the first instar grubs.

Table 32. PROGRAMME OF WORK (ENTOMOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Ent. I (231)	Investigations on rhinoceros beetle *Oryctes rhinoceros L.*	Kayangulam
	1. Chemical control	
	i) Laboratory studies	
	(a) Insecticidal trials against adults of *Oryctes rhinoceros*	
	(b)* Studies using granular insecticides *viz.* sevidol, lindane etc., against grubs and adults of *Oryctes* and the predators *Santalus* sp. and *Agrypnus* sp.	
	ii) Field studies	
	(a) Field control of rhinoceros beetle using carbaryl	

Project No.	Name of the Project	Venue
	(b) Maintenance of a permanent demonstration-cum-trial plot of rhinoceros beetle control using BHC (c) Screening tests with chemical attractants 2. Biological control i) Parasites : using nematode DD-136 ii) Predators: field introduction and colonisation of *Platymeris laevicollis* iii) Pathogens (a) Trials using *Metarrhizium anisopliae* (b) Trials using *Rhabdionvirus oryctes* (c) Studies using bacteria 3. Analysis of insecticide residues	
Ent. II (231)	Investigations on leaf eating caterpillar, *Nephantis serinopa* M. 1. Chemical control i) Bioassay of insecticides singly and in combination against the pest ii) Contact effect of recommended doses of insecticides against adults of *Nephantis serinopa* iii) Bioassay of insecticides against the parasites 2. Biological control i) Breeding of parasites ii) Fixing up a norm for the release of indigenous laboratory bred parasites for the control of *Nephantis serinopa*	Kayangulam

Project No.	Name of the Project	Venue
	iii) Introduction and trial of the exotic parasite *Spoggosia bezziana* Bar., against *N. serinopa* 3. Integrated control Field studies on the control of the pest using insecticides and parasites	
Ent. III (231)	Investigations on the red palm weevil *Rhynchophorus ferrugineus* F. 1. Chemical control i) Laboratory tests using garlic extract against the grubs of red palm weevil ii) Field tests using mevinphos, phostoxin, etc. 2. Integrated control Maintenance of a garden free of infestation by adoption of all proved methods of weevil control 3. Sterile male release method for the control of red palm weevil 4. Analysis of insecticide residues	Kayangulam (Collaboration with Bhabha Atomic Research Centre, Trombay)
Ent. V (231)	Studies on minor pests of coconut 1. Studies on mites 2. Control of rats 3. Studies on new pests	Kayangulam
Ent. VI (231)	Estimation of crop losses due to pests of coconut	Kayangulam

*Trials to be initiated after completion of the studies

i) subject to approval by the 1974 Research Council Meeting

EXTENSION

Ext. I (231). National seed production

(M. K. Muliyar, K. U. K. Nampoothiri, K. J. Antony, C.P. Radhakrishnan Nair, and Nursery Asst., (Kasaragod)

A total of 3,508 seedlings, consisting of 1, 500 seedlings of WCT, 1,221 Dwarf Orange, 460 Dwarf Green, 130 Malayan Dwarf, 117 hybrids, and 80 miscellaneous were planted in the Kidu Farm, Subramanya Including this, the number of seedlings distributed to cultivators, government institutions and government departments during the year was 22,848 seedlings of WCT, 3,455 Dwarf, 1,556 DxT 2,400 varieties, and 5,630 other hybrids. Further, 20,540 seednuts of WCT, 2,810 of Dwarf Orange, and 1036 of Dwarf Green were sown in the nursery.

Ext. II (231). Setting up of demonstration plots

(K. Sethumadhava Menon, M.K. Muliyar, K.J. Thommen, C. P. Radhakrishnan Nair, and K. J. Antony)

Five new demonstration plots were set up in Kerala and Karnataka covering different soil types. They are in the gardens of Shri R. P. Kotekar, (Ullal), Shri K. C. Naik, (Vorkady), Shri T. K. Abdulkhader, (Karicherry), Shri M. K. Nambiar, (Odayanchal), and Dr. P. N. Ariga, (Puttur). This brings the total number of demonstration plots to 14.

Under the auspices of the Kayangulam Station, 51 demonstration plots were set up during the year for studying the varietal reaction to root (wilt) disease. There are now 82 such plots in the region.

Ext. III (231). Training of extension and research workers and farmers

(M. K. Muliyar, K. J. Antony, and C. P. Radhakrishnan Nair)

Training was imparted to eleven research workers and development officers from the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Orissa, and Mizoram. Nineteen officers from the Agriculture and Horticulture Departments of Kerala, Tamil Nadu, Pondichery, Karnataka, Andhra Pradesh, and Gujarat, and 24 instructional staff of Farmers' Training

Centres were also given training on different aspects of plantation crop cultivation.

Ext. IV (231). Fertilizer trials in cultivators' garden

(M. K. Muliyar, M. P. Sankaranarayanan, K. K. N. Nambiar, C. P. Radhakrishnan Nair, and Jacob Mathew)

In order to find out the most economic levels of manuring under field conditions, 12 trials have been laid out in the lateritic soils of Kasaragod Block. The trial has three treatments, *viz.*, the cultivators' practice, the recommended dose of fertilizers for the well maintained garden, and the recommended dose for the average maintenance. All the inputs are supplied free by the Institute. Data will be recorded for five years to work out the economics of fertilizer application.

The first round of fertilizer application was done in September, and nut yield and the number of leaves were recorded. Soil and leaf samples collected from these plots are being analysed.

Ext. V (231). Operational research project

(M. K. Muliyar, K. V. A. Bavappa, E. V. Nelliat, K. Satyabalan, Jacob Mathew, G. B. Pillai, and N. G. Pillai)

This project envisages a comprehensive planning and development of a selected area on all aspects of agriculture, animal husbandry, fisheries, and forestry based on an integrated land use. The object is to adapt the new agricultural technology to the actual field conditions and demonstrate it in farmers' fields, to assess the economics of the new technology, and to find out the minimum economically viable land holding for a family. It is being carried out in three villages, Muttathody, Chengala, and Kudlu of Kasaragod NES Block and is run in collaboration with several other agencies such as Kerala State Departments of Agriculture, Animal Husbandry and Co-operation, Small Farmers' Development Agency, Kasaragod NES Block, Syndicate Bank, Kerala Agro Industries Corporation, Fisheries College, Mangalore, (University of Agricultural Sciences, Hebbal), Centre for Development Studies, Trivandrum, Kerala Agricultural University, Kerala State Hydrologist, Kerala State Electricity Board, Rural Engineering Survey Unit, and Farmers' Training Centre, Taliparamba.

The bench mark survey of all the households in Muttathody village was completed. It is being tabulated and analysed now.

Table 38. PROGRAMME OF WORK (EXTENSION) FOR 1974

Project No.	Name of the Project	Venue
Ext. I (231)	National seed production	Kasaragod, Vittal, and Kidu
Ext. II (231)	Setting up of demonstration plots	Throughout India
Ext. III (231)	Training for instructional staff of Farmers' Training Centres and extension and research workers	Kasaragod, Vittal, and Kayangulam

GENETICS

SUMMARY

The cumulative yield data of 16 exotic introductions for nine years showed that Mangala, VTL-11, VTL-12, VTL-13, and VTL-17 gave 6-50% more yield over the local type. Among the nine indigenous cultivars, Sweet Areca and Thirthahalli yielded significantly high than the local type. The chromosome pairing in the pollen mother cells of *Areca triandra* types and their F_1 hybrids with *Areca catechu* was found to be distributive in nature. Karyomorphological differences were recorded among nine cultivars of *A. catechu*, but the karyotype was nearly uniform in *A. triandra*. By using colchicine, tetraploids were produced in two *A. catechu* cultivars. A total of 93 intervarietal, interspecific, and intergeneric crosses were made during the year. It was noted in the experiment to fix selection standards that the differences in yield due to selection of seednuts were not significant. Variations due to mother palms were highly significant for certain morphological characters in the mass pedigree selection trial. Secondary selection was initiated in Mangala to bring about homogeneity for appearance and yield.

Work in progress

Bot. I (131). **Introduction and maintenance of indigenous and exotic species and types of *Areca* for selection, hybridisation, and cytogenetic studies**

(M. K. Nair, R. S. N. Pillai, and M. J. Ratnambal)

In 1972–73, the yield data of 16 exotic types from Sri Lanka, China, Solomon Islands, Fiji, Indonesia, Mauritius, Thailand, and Singapore showed significant differences between the cultivars for number and weight of nuts per palm. VTL–2 (Mauritius) produced the maximum number of nuts followed by VTL–7 (Indonesia–2) and VTL–21 (Sri Lanka–3) (Table 34). When the average yield per palm was considered, the Local type came first VTL–12 (Saigon–1) was second, and VTL–11 (Indonesia–6) third.

Table 34. Performance of 16 exotic introductions

Sl. No.	Name of the type	Accession number	1972 – 1973		1964 – 1965 to 1972 – 1973 (Average 9 years)
			Mean no. of nuts per tree	Mean weight of nuts per tree (kg)	Weight of nuts per tree
1	Fiji	VTL–1	132	3.1	3.1
2	Mauritius	VTL–2	5828	13.2	6.1
3	Mangala	VTL–3	198	7.0	10.3
4	Sri Lanka	VTL–5	391	12.1	6.9
5	Indonesia–1	VTL–6	582	2.2	1.4
6	Indonesia–2	VTL–7	3242	10.9	8.2
7	Sri Lanka–2	VTL–15	216	11.1	6.7
8	Indonesia–6	VTL–11	546	13.6	14.5
9	Saigon–1	VTL–12	512	19.4	12.9
10	Saigon–2	VTL–13	184	7.2	11.7
11	Saigon–3	VTL–14	507	13.3	9.0
12	Singapore	VTL–17	252	10.2	14.6
13	Solomon Islands–1	VTL–18a	189	4.8	2.7
14	Solomon Islands–2	VTL–18b	256	7.2	5.1
15	Solomon Islands–3	VTL–18c	308	5.7	3.2
16	Sri Lanka–3	VTL–21	2063	5.7	2.6
17	Local	South Kanara type	682	22.7	9.7
	S. E. per plot		830	7.0	3.9
	Overall mean		946	10.0	7.6
	C. V. (%)		88	70.1	52.0
	C. D. (P = 0.05)		479	4.0	4.5

Table 35. Performance of nine indigenous *A. catechu* (cultivars) for 1972 - 1973

Sl. No.	Name of the cultivar	Mean number of nuts per palm	Mean weight of nuts per palm
1	Sweet Areca	845	20.7
2	Thirthahalli	1352	18.9
3	Chickamagalore*	416	8.5
4	Hirehalli	418	10.8
5	Peechi	301	10.2
6	Mettupalayam	271	5.0
7	Mohitnagar	318	10.5
8	Assam	218	6.3
9	Local	289	11.3
	C. D. (P = 0.05) for comparing any two treatments except Chickamagalore	391	7.3
	C. D. (P = 0.05) for comparing Chickamagalore and any other cultivar	402	7.5

*** Based on mean of nine palms; all others based on mean of ten palms**

Statistical examination of the cumulative yield data of the above varieties for nine years (1964–65 to 1972–73) revealed that the five introductions, *viz.*, Mangala (VTL–3), VTL–11 (Indonesia), VTL–12, VTL–13 (Thailand), and VTL–17 (Singapore) gave 6–50% more yield than the local type (Table 34). The nut yields of VTL–17 and VTL–11 were significantly higher than that of the local type. The yields of VTL–17, VTL–11, Mangala, VTL–12, and VTL–13 were not significantly different. The *A. triandra* VTL–7 (Indonesia–1) gave the lowest yield during these nine years.

During the year, no significant differences in number and weight of nuts were observed among the 12 types belonging to the second batch of introductions from Andamans, Australia, Fiji, and Saigon. On the other hand, the number and weight of nuts of nine *A. catechu* cultivars collected from within the country differed significantly. Sweet Areca and Thirthahalli were the best yielders. (Table 35).

Meiotic studies in *A. catechu*, *A. triandra*, and *A. catechu*, x *A. triandra* hybrids indicated the occurrence of distributive pairing in *A. triandra*, and the F_1 hybrids.

Considerable karyomorphological differences were noticed among the nine cultivars of *A. catechu*. The karyotype of the four *A. triandra* types were relatively more uniform.

By using colchicine, tetraploids (2n=64) were produced for the first time in two *Areca* cultivars, Mangala and VTL-11.

Bot. V (131). **Hybridisation between exotic and indigenous types and species**

(K. V. A. Bavappa, M. K. Nair, and M. J. Ratnambal)

A total of 93 controlled crosses were made as under:

1) Intervarietal crosses in *A. catechu* to combine dwarfness (of the Hirehalli Dwarf mutant available in the germplasm), superior nut quality (of Sreevardhan), resistance to yellow leaf disease (of Mohitnagar) and high yield (of Mangala (VTL-3), VTL-11, VTL-12, VTL-13, and Thirthahalli) ;

2) Selfing the interspecific hybrid *A. catechu* × *A. triandra* and also back-crossing it to high yielding cultivars of *A. catechu* in an effort to increase the fertility in the F_1 hybrids and to combine the desirable characters of both the species ; and

3) Interspecific and intergeneric hybrids involving *A. catechu*, *A. normanbyii*, *A. triandra*, *A. macrocalyx*, and *Actinorhytis calapparia*, to study the inheritance of certain morphological characters and phylogenetic relationship.

The total number of seeds obtained in the above crossings were raised in the primary nursery.

Bot. VI (131). **Efficiency of phenotypic selection of mother palms, seednuts, and seedlings**

(M. J. Ratnambal, Asst. Statistician, (Vittal), Asst. Agronomist, (Vittal), and K. Vijaya Kumar)

The experiment started in 1963-64 with the objectives of fixing selection standards for mother palms, seednuts, and seedlings, has the following six treatments: (1) unselected bulk nuts, (2) selected bulk nuts, (3) unselected nuts from mother palms, (4) selected nuts from mother palms, (5) selected nuts from non prepotent mother palms, and (6) selected nuts from prepotent mother palms.

The analysis of yield data for 1972-73 of the treatments (1) to (4) showed that the differences due to selection were not significant for number and weight of nuts per palm per year.

Bot. VII (131). **Improvement by mass pedigree selection**

(Asst. Botanist, (Vittal), K. Vijaya Kumar, and Asst. Statistician, (Vittal)

Among the progenies of 16 selected mother palms and two controls planted in 1968, 67% palms have started flowering. There were no significant differences between families as well as within families for the number of palms flowered.

Variations due to mother palms were highly significant in the progenies for total height, number of leaves, number of nodes, girth at permanent mark, and girth at last exposed node. When this variation was further split into different components, significant differences were observed within the family whereas they were absent between families (KMJ-3 *vs.* KMJ-8, SDK-15 *vs.* KMJ-3 + KMJ-8) for any of these characters except for girth at permanent mark. The girth at permanent mark was significantly more in the progenies of KMJ-3 and KMJ-8 families than in the progenies of family SDK-15.

The differences between two controls and selected families were not significant for any of the characters. Progenies of mother palm 45 (KMJ-8 family) continued to show higher values than others for all the characters.

Bot. XIII (131). **Secondary selection in Mangala**

(N. M. Nayar and M. K. Nair)

Mangala is the name given to VTL-3, one of the 34 accessions that has been released for general cultivation. It is semitall, early bearing, and begins to bear in the third year after planting against five years taken by the local type. Since the plant population about 300, available in the Station was showing, heterogeneity, secondary selection was initiated in the cultivar to bring about homogeneity both in appearance and performance.

Based on appearance and yield, the palms were tentatively grouped into three classes, high yielders, medium yielders, and low yielders. Each class was further subdivided into tall and semitall. Twenty typical (high yielding, semitall) Mangala palms were selected and they were crossed in single crosses and polycrosses. They were also self-pollinated and allowed to open-pollinate. Over 1700 nuts obtained from the above crosses were sown in the primary nursery to raise seedlings.

Table 36. PROGRAMME OF WORK (GENETICS) FOR 1974

Project No.	Name of the Project	Venue
Bot. I (131)	Introduction and maintenance of indigenous and exotic species and types of *Areca* for selection, hybridisation, and cytogenetic studies	Vittal and Palode
Bot. V (131)	Hybridisation between exotic and indigenous species and types	Vittal
Bot. VI (131)	Efficiency of phenotypic selection of mother palms, seednuts and seedlings	Vittal
Bot. VII (131)	Improvement by mass pedigree selection	Vittal
Bot. XIII (131)	Secondary selection in Mangala	Vittal
All India Co-ordinated Project		
Experiment 6	Trial of promising arecanut varieties	Thirthahalli, Coimbatore, Ratnagiri and Kidu

AGRONOMY

SUMMARY

At Peechi, arecanut palms planted at a spacing of 2.7m x 2.7m yielded the maximum number and weight of nuts per plot. At Hirehalli, the yield was maximum under the spacing 1.8m x 3.6m, and at Kahikuchi, it was in the spacing 1.8m x 2.7m. Palms planted 90 cm deep and irrigated once in five days gave the highest yield of nuts at Vittal. Of the six introductions of cacao tried at Peechi as a mixed crop with arecanut, the hybrid I 195 x ICS 60 gave the highest yield. At Vittal the analysis of both original and revised fertilizer schedules showed response to nitrogen and green leaf. At Kahikuchi and Peechi also, the response to nitrogen was significant.

Work in progress

Agr. II (131). **Determination of optimum spacing in the main field**

(K. Shama Bhat, C. K. George, Res. Asst., (Kahikuchi), and B. Nagaraj)

The experiment is in progress at three substations, *viz.*, Peechi, Hirehalli, and Kahikuchi. In all the centres data on leaf fall, production of spadices, number and weight of fruits harvested were recorded. The yield data are summarised and given in Table 37

Table 37. Effect of spacing on nut yield

Treatments	Peechi		Hirehalli		Kahikuchi	
	Yield/plot		Yield/plot		Yield/plot	
	Nut no.	Fruit wt. (kg)	Nut no.	Fruit wt. (kg)	Nut no.	Fruit wt. (kg)
1.8 m x 1.8 m	6092	163 . 6	13904	231 . 8	2025	70 . 1
1.8 m x 2.7 m	6442	164 . 8	13607	229 . 6	5027	176 . 4
1.8 m x 3.6 m	6328	159 . 6	13594	249 . 9	4465	152 . 3
2.7 m x 2.7 m	6560	174 . 3	15090	243 . 9	4617	160 . 1
2.7 m x 3.6 m	5946	153 . 2	10649	196 . 8	4470	154 . 0
3.6 m x 3.6 m	4986	135 . 2	6471	118 . 3	3077	106 . 7
Gen. mean	6059	158 . 4	12219	211 . 7	3947	136 . 6
C. D. (5% level)	—	—	3795	60 . 2	1074	31 . 5

At Peechi, there was no significant difference in yield (both in number and weight) between different treatments, although the highest yield was obtained in the 2.7m x 2.7m spacing. At Hirehalli, though the yield (by weight) was maximum in the spacing 1.8m x 3.6m it was not significantly superior to any of the other treatments except the 3.6m x 3.6m spacing. At the same time, the number of nuts was maximum in the spacing 2.7m x 2.7m. At Kahikuchi, maximum yield was obtained from the spacing 1.8m x 2.7m but it was not significantly more than that of the other spacings excepting 1.8m x 1.8m and 3.6m x 3.6m.

Agr. IV (131). Effect of different intervals of irrigation at different depths of planting

(K.B. Abdul Khader, C.K. George, Res. Asst., (Palode), Res. Asst., (Kahikuchi)

This experiment was laid out to determine the optimum depths of planting *Areca* seedlings and optimum intervals of irrigation under different agro-climatic conditions.

At Vittal, the experiment was initiated in 1966 using a 4 x 3 x 5 strip plot design with four intervals of irrigations, *viz.*, 5, 10, 15, and 20 days and three depths of planting at 30, 60, and 90 cm. The nut yield and nut number obtained during 1972–73 were significantly affected by both intervals of irrigation and depths of planting. Irrigation at intervals of 5 and 10 days were superior to the 15 and 20 days treatments. Also, planting at 90 cm significantly increased the yield as compared to the other depths of planting.

At Hirehalli, intervals of irrigation did not significantly affect morphological characters of the palm. On the other hand, arecanut planted at 60 cm depth significantly increased internodal distance. The interaction between the intervals of irrigation and depths of planting were significant for growth characters.

At Kahikuchi, irrigation once a week gave significantly more leaves than irrigation once in three weeks. It also produced more spadices and bunches than the treatments, no irrigation and irrigation once in three weeks.

Agr. VI (131). Intercropping experiment

(B. Nagaraj, C. K. George, K. J. Abraham, Res. Asst., (Hirehalli), Res. Asst., (Kahikuchi), and Res. Asst., (Mohitnagar)

1. Arecanut and banana

This experiment laid out in a 8 × 4 randomised block design was started at Vittal in 1963 to determine if banana could be grown successfully as an intercrop with arecanut. During 1972–73, the growth characters, leaf fall, spadices produced, and yield of nuts were not significantly affected by the different treatments. The treatments consisted of (1) no banana throughout the period of the experiment (i. e., pure *Areca* plantation), (2) banana as intercrop throughout the period of experiment at full level, (3) banana at full level for three years and no banana thereafter, (4) banana at full level for three years and reduced level for the rest of the period, (5) banana at full level for three years and reduced level for the next three years, (6) banana at full level for six years and no banana thereafter, (7) banana at full level for six years and then at reduced level for the rest of the period, and (8) banana at

full level for six years, reduced level for the next four years and no banana thereafter.

The three stages, *viz.*, third, sixth, and tenth years fixed above, correspond to three distinct phases of arecanut, *viz.*, period of formation of distinct nodes, flowering, and attainment of full bearing stage. Treatments 2, 4 and 7 were replanted in November.

2. Arecanut and other crops

A variety of intercrops, are being raised in the farms of the regional and substations along with arecanut. At Vittal, observational plots were maintained with pineapple, banana, guinea grass, cardamom, and coffee. Intercrops like ginger, pineapple, and elephant foot yam were successfully grown at Peechi without affecting the yield of main crop. At Palode, elephant foot yam and *Dioscorea* gave good yields with a net return of about Rs. 1750/ha. Betelvine was found to be a promising intercrop at Hirehalli. The crops banana, betelvine, and pineapple, were found to grow well in the arecanut gardens at Mohitnagar.

Agr. VII (131). **Mixed cropping experiment**

(K. Shama Bhat, C. K. George, and K. J. Abraham)

1. Arecanut and cacao

(i) A mixed garden of arecanut and cacao (var. criollo) was planted at Vittal in 1964 in an observational trial with three treatments, *viz.*, (1) arecanut and cacao in equal numbers (spacing 4m x 4m – quincunx method), (2) arecanut as pure crop, and (3) cacao as border crop in *Areca* garden. The seventh year crop of cacao was harvested during the year and the trees under treatment (1) gave on an average, 76.8 pods per tree and those under treatment (3) had a mean yield of 21.7 pods per tree. The number of nuts produced per tree under the treatments (1), (2), and (3) were 391.1, 210.0, and 242.1, respectively. The cacao trees under treatment (3) suffered badly due to sun burn.

(ii) Another experiment is in progress at Vittal since 1970 on a 6x2x4 confounded asymmetrical factorial design, using Forastero variety of cacao and local (South Kanara) variety of *Areca*. It has six spacing and two manuring treatments.

The first crop of cacao was harvested from a few trees in 1972. Almost 60% of the trees came to bearing during the year. The *Areca* palms have outgrown the cacao trees in height and commenced flowering during the year.

(iii) Another experiment has been laid out in 1969 using six intraracial hybrids obtained from Sabah (Malaysia), at Peechi under irrigated conditions,

and at Palode under rainfed conditions, adopting a 2x2x6x2 split plot design. The trial compares two methods of alignment, two levels of manuring and six crosses. At Peechi, the variety V_3 (I 195 x ICS 60) recorded the highest yield (mean: 75.5 pods weighing 20.07 kg per tree). Cacao planted in the quincunx method and at the lower level of manuring (100g N, 40g P_2O_5 and 140g K_2O) produced more pods (number and weight) and beans (weight). At Palode also, the variety V_3 (I 195 x ICS 60) performed better than the others. Similarly, the performance of cacao planted by the quincunx method was better than that by the square system.

Agr. VIII (131). **Effect of different methods of intercultivation on the productivity of palms**

(M. Sannamarappa, K. J. Abraham, and C. K. George)

This experiment to study the effect of different methods of intercultivation on the productivity of the palm was laid out at Peechi, Palode, and Hirehalli during 1967 in a 6 x 4 randomised block design. At Hirehalli, digging with mammaty fork twice a year gave higher yield. At Peechi, none of the treatments produced any significant effect on either yield or growth characters. At Palode, planting on terraces made along the contour together with clean cultivation and manuring was better than other methods.

Agr. IX (131). **NPK manurial experiment**

(K. B. Abdul Khader, K. Shama Bhat, M. Achuthan Nair, A. R. Mohapatra, Res. Asst., (Hirehalli), Res. Asst., (Mohitnagar), and Res. Asst., (Kahikuchi)

This experiment was laid out at Vittal, Peechi, Hirehalli, Mohitnagar, and Kahikuchi for finding out the NP and K requirements under varied soil and climatic conditions.

At Vittal, the experiment was laid out in 1961 on a 3^4 confounded factorial design in a single replication with nine plot blocks. In 1972, the treatments were modified to include higher fertilizer levels.

Accordingly, the original levels of NPK and green leaf were retained in one half of each main plot and the revised doses were superimposed on the palms of the other half of the plot (Table 38). At Peechi, the revised levels were tested with and without lime as subplot treatments. The fertilizers and green leaf were applied in two split doses in September-October and February-March.

Table 38. The original and revised manurial doses of the NPK experiment at Vittal

Nutrients	Original levels			Revised levels		
N (g/palm)	0	50	100	50	100	200
P_2O_5 ,,	0	40	80	40	80	160
K_2O ,,	0	70	140	70	140	280
Green leaf (G) (kg/palm)	0	7	14	7	14	21

At Vittal, the yield data for 1972–73 revealed that the response to N was highly significant for both number and wet weight of nuts. Application of 50 gm N per palm gave the maximum yield. It was significantly higher than that of control, but not than that of 100 g N per palm. The nutrient interaction had no effect of nut number, but the treatment N_1K_2 significantly increased the weight of ripe nuts.

In the revised schedule, application of 100 g N significantly increased the yield components like number and weight of nuts. Application of green leaf also increased the number and weight of nuts significantly. Treatment interactions were not significant for any of the yield characters.

At Hirehalli, N and G significantly increased the number and wet weight of nuts. N_1 and N_2 gave significantly more number and wet weight of nuts than N_0. Similarly, G_1 and G_2 were significantly superior to G_0. The interaction effects of NP and NK were highly significant for all the characters except leaf fall. The treatments N_1P_1 and N_2K_1 were superior to the other interactions in increasing the yield of nuts. N_1P_2 recorded more leaf fall than N_0P1, N_0P_2 and N_2P_0. Similarly, N_2K_1 significantly increased the leaf fall as compared to N_0K_0,, N_0K_1, N_0K_2 and N_2K_2 in respect of leaf fall.

At Peechi, the main effect of green leaf was significant for number and wet weight of nuts. For both these characters G_2 was significantly superior to G_1. P_2 increased the wet weight of nuts over P_0 and P_1 in the absence of K. NP interaction was significant for number of nuts and PK and PG interactions for wet weight of nuts. The maximum yield was recorded in the treatment N_1P_2. P_1K_1 was superior to P_1K_2 in increasing the wet weight of nuts. G_2 gave significantly more fresh weight of nuts with higher doses of P.

At Kahikuchi, the main effect of N was significant for number of shed leaves, bunches harvested, nut number, and wet weight of nuts. K was significant for number and wet weight of nuts. N_2 gave significantly more

leaf fall than N_0 and N_1. N_2 and N_1, although at par with each other, both increased significantly the number and wet weight of nuts than N_0. None of the interactions was significant.

Agr. XI (131). **Placement and fractional application of fertilizers**

(C. K. George and M. Achuthan Nair)

This experiment was laid out at Peechi in October, 1968 in a 6x5 randomised block design to study the effect of fractional application of fertilizers on the yield and growth of arecanut crop. The treatments were (1) NPK in one application in September, (2) NPK in two applications in September and January, (3) NPK in three applications in September, January, and April, (4) PK in one dose in September and N in two doses in September and January, (5) NP in one dose in September and K in two doses in September and January, and (6) P in one dose in September and NK in two doses in September and January.

The fertilizers were applied at the rates of 100g N, 40g P_2O_5, and 140g K_2O per tree per annum, using calcium ammonium nitrate, rock phosphate, and muriate of potash. An annual dose of 12 kg green leaf was given uniformly to all the palms in September.

The results obtained, so far, showed that fractional application of fertilizers has not significantly increased the yield of arecanut or altered any of the growth characters under observation.

Agr. XIII (131). **Root studies of arecanut palms of different ages and under different soil conditions**

(K. J. Abraham)

The study was undertaken at Palode using 11 year old arecanut palms raised on a steep hill slope. The spread of root was studied on the lower as well as on the upper end of slopes. The maximum concentration (70%) of roots was present within 60 cm of the ground level. The spread of roots was confined to a radius of 75 cm of the palm on the upper side of the slope and to 100 cm radius on the lower slope. The total amount of roots on the lower slope was higher than that on the upper slope.

Agr. XIV (131). **Crop weather study**

(Nursery Asst., (Vittal), E. I. Antony, K. K. K. Nambiar, T. Kempanna, Harilal, and Mahavir Singh)

Data on rain fall, temperature, humidity and other weather parameters were recorded at the regional and substations (Tables 39, 40, 41, and 42). Duration of bright sun shine and evaporation were also recorded at Vittal.

Agr. XV (131). **Economics of arecanut cultivation**

(M. Vijayarajan, E. I. Antony, K. K. K. Nambiar, T. Kempanna, R. K. Singh, and Harilal)

Data on cost of cultivation were maintained in the regional and substations.

At Vittal, the total cost of cultivation per hectare came to Rs. 5970.44. The yield of *chali* was 3760 kg/ha. At Hirehalli, the corresponding figures were Rs. 3350.00 and 1920 kg/ha. At Palode, data were collected under rainfed conditions. Here the cultivation cost amounted to Rs. 2965.00/ha and the income was Rs. 2200.00. At Peechi, the cultivation charges came to Rs. 4395.00/ha. The garden has not yet come to full bearing.

Table 39. WEATHER DATA, VITTAL 1978

Month	No. of rainy days	Total rain fall in mm	Mean for previous five years		Maximum temperature in °C		Minimum temperature in °C	
			No. of rainy days	Rain fall in mm	Highest	Lowest	Lowest	Highest
January	Nil	Nil	Nil	Nil	36.7	30.5	17.1	22.3
February	Nil	Nil	Nil	N.l	35.8	33 0	18.3	22.3
March	Nil	Nil	Nil	0.7	39.7	34.4	20.1	24.7
April	1	17.8	2.6	50.3	36.6	33.5	22.8	26.3
May	6	74.0	6.6	151.1	36.0	30.8	22.3	26.3
June	28	1086.7	23.0	975.1	34.5	26.0	21.6	24.8
July	27	950.6	29.8	1442.7	30.7	26.5	22.0	23.8
August	29	827.6	24.2	717.3	29.5	25.3	21.8	23.8
September	8	76.3	16.2	346.0	31.6	27.5	21.6	23.8
October	9	115.4	10.4	176.0	35.1	28.0	22.5	23.6
November	4	85.8	3.8	100.9	34.5	29.5	16.3	24.3
December	4	21.1	1.2	6.2	34.3	30.3	15.8	22.2
Total	116	3255.3	117.8	3966.3	—	—	—	—

Humidity percentage		Evaporation in mm (U. S. A. pan)		Mean sunshine hr/day	Remarks
Highest	Lowest	Highest	Lowest		
98	23	6.2	3.1	9.8	
98	23	7.5	4.4	10.3	
96	13	6.9	5.0	9.8	
96	43	7.7	4.2	9.0	
97	37	9.3	4.0	8.6	
98	58	6.0	1.5	2.9	
98	65	4.3	1.5	3.8	
100	72	4.0	0.9	2.4	
98	60	5.1	1.7	6.3	
98	47	4.9	2.1	6.4	
98	23	5.6	2.4	9.2	
98	29	6.9	3.3	9.1	
—	—	—	—	—	

Table 40. WEATHER DATA, MOHITNAGAR AND KAHIKUCHI, 1973

Month	MOHITNAGAR										KAHIKUCHI	
	No. of rainy days	Rainfall in mm	Mean no. of rainy days for last 5 years	Mean rainfall for last 5 years	Highest max. temperature in °C	Lowest max. temperature in °C	Lowest min. temperature in °C	Highest min. temperature in °C	Highest humidity %	Lowest humidity %	No. of rainy days	Rain fall in mm
January	1	3.0	1.2	6.2	27.8	20.5	5.4	10.5	97	29	1	4.0
February	—	—	1.4	6.8	30.2	25.1	9.0	14.3	95	29	3	30.4
March	—	—	2.6	25.3	36.5	27.5	11.6	17.3	93	10	2	33.0
April	5	99.4	7.6	115.0	39.3	28.9	16.5	24.2	95	26	5	123.6
May	18	265.8	10.8	184.4	33.3	28.0	18.4	24.0	98	46	15	225.5
June	26	676.7	20.6	648.0	32.3	25.7	22.5	25.5	100	69	17	256.1
July	17	421.1	23.6	770.4	34.3	28.1	24.2	26.8	98	65	12	245.8
August	6	440.0	22.2	474.2	36.3	28.2	23.0	25.8	100	59	11	173.5
September	15	613.9	15:0	503.8	33.9	26 6	22.4	24.8	100	67	11	224.4
October	8	308.2	3.8	196.7	33.1	26.5	17.5	23.8	100	55	5	102.3
November	1	6.0	1.6	13.8	31.5	26.6	12.6	18.9	98	42	3	48.2
December	—	—	—	—	30.0	24.0	8.3	12.8	98	29	1	35.0
Total	97	2834.1	110.4	2944.6	—	—	—	—	—	—	86	1501.8

KAHIKUCHI

Mean no. of rainy days for 5 years	Mean rainfall for last 5 years	Temperature in °C				Mean humidity %	Remarks
		Highest maximum	Lowest maximum	Lowest minimum	Highest minimum		
2.2	12.8	—	—	4.5	10.5	74	Data in respect of max. temperature could not be collected for want of instrument
1.8	12.3	—	—	7.5	14.0	61	
5.0	39.1	—	—	10.0	20.0	62	
12.0	146.5	—	—	15.0	21.5	68	
14.6	188.1	—	—	15.3	24.5	59	
19.0	361.4	—	—	18.0	25.0	89	
16.2	354.2	—	—	21.0	27.5	78	
14.8	306.6	—	—	21.2	26.0	80	
10.6	137.5	—	—	21.0	25.5	80	
5.4	76.5	—	—	15.0	24.0	76	
1.6	23.1	—	—	9.0	17.0	80	
—	—	—	—	6.5	11.5	77	
103.2	1660.1	—	—	—	—	—	

Table 41. WEATHER DATA, PEECHI

Month	PEECHI							
	No. of rainy days	Rainfall in mm	Mean no. of rainy days for last 5 years	Mean rain fall for the last 5 years	Temperature °C			
					Highest maximum	Lowest maximum	Lowest minimum	Highest minimum
January	Nil	Nil	Nil	Nil	33.0	28.0	11.0	17.5
February	Nil	Nil	0.4	12.9	36.0	31.0	13.0	19.0
March	Nil	Nil	0.6	12.9	36.5	30.0	14.0	18.0
April	6	167.6	5.0	74.9	37.0	29.0	15.0	19.5
May	6	101.4	11.6	278.4	55.0	28.0	14.5	20.0
June	25	602.4	33.4	703.7	33.5	24.0	14.5	19.0
July	19	538.0	28.0	983.9	30.0	23.0	13.5	18.0
August	28	490.5	21.8	460.6	29.5	22.5	14.5	17.0
September	4	16.4	13.0	226.0	—	15.0	—	17.5
October	20	231.5	12.6	224.2	32.0	25.0	12.5	19.0
November	4	40.5	3.8	79.6	32.5	26.5	12.5	17.0
December	3	26.6	1.8	66.8	32.0	23.5	11.5	16.0
Total	115	2214.9	122.0	3123.9	—	—	—	—

Remarks	PALODE						Remarks
	No. of rainy days	Rainfall in mm	Mean no. of rainy days for last 3 years	Mean rainfall for last 3 years	Mean temperature °C		
					Maximum	Minimum	
The highest and the lowest maximum temperature data are based on Peechi observatory readings sincethis Station thermometer had broken.	1	11.0	2.7	38 8	34.7	12.3	
	Nil	Nil	2.7	39 2	36.0	13.5	
	5	93.8	7.0	70.7	36.5	15.8	
	21	419.4	17.7	297.2	35.7	19.0	
	9	254.6	12.3	363.8	35.2	19.3	
	23	596.4	17.3	289.7	33.3	19.2	
	15	235.2	18.0	270.1	31.8	19.3	
	21	205.0	11.7	156.2	33.0	19.3	
	7	78.8	12.7	260.4	33.8	18.9	
	19	568.6	18.0	502.5	31.7	18.3	
	10	113.0	8.7	193.7	34.0	16.2	
	13	155.2	6.3	62.2	34.4	12.8	
	144	2731.0	135.1	2544.5	—	—	

Table 42. WEATHER DATA, HIREHALLI, 1973

Month	No. of rainy days	Rainfall in mm	Mean for last five years		Temperature °C				Remarks
			No. of rainy days	Rainfall in mm	Highest maximum	Lowest maximum	Lowest minimum	Highest minimum	
January	Nil	Nil	Nil	Nil	Not recorded as the equipment was out of order		5.0	15.0	
February	Nil	Nil	Nil	Nil			14.5	19.0	
March	Nil	Nil	0.5	2.0	36.0	30.0	15.0	28.0	
April	1	21.8	3.4	47.1	36.0	33.0	11.0	29.0	
May	9	91.9	9.0	180.2	34.0	28.0	20.5	25.0	
June	13	102.5	8.8	68.0	31.5	25.0	20.0	25.0	
July	11	103.8	8.6	82.0	29.0	23.0	19.0	22.0	
August	21	205.5	15.8	22.0	28.0	24.0	19.0	21.5	
September	11	161.3	10.2	163.4	29.5	25.0	18.0	22.0	
October	13	291.6	10.4	190.7	30.0	26.0	16.5	21.0	
November	1	19.4	3.2	27.5	28.0	25.0	11.5	21.0	
December	Nil	Nil	1.0	10.9	28.5	20.5	10.0	19.5	
Total	80	997.8	70.9	981.8	—	—	—	—	

Table 43. PROGRAMME OF WORK (AGRONOMY) FOR 1974

Project No.	Name of the Project	Venue
Agr. II (131)	Determination of optimum spacing in the main field	Vittal, Hirehalli, Peechi, and Kahikuchi
Agr. IV (131)	Effect of different intervals of irrigation at different depths of planting arecanut	Vittal, Hirehalli, Kahikuchi, Palode, and Mohitnagar
Agr. VI (131)	Intercropping experiments – a. arecanut and banana b. arecanut and other crops	Peechi, Hirehalli, Mohitnagar, Palode, Kahikuchi, and Vittal
Agr. VII (131)	Mixed cropping experiments – arecanut and cacao	Vittal, Peechi and Palode
Agr. VIII (131)	Effect of different methods of intercultivation on the productivity of palms	Peechi, Palode, and Hirehalli
Agr. IX (131)	NPK manurial experiment	Vittal, Peechi, Hirehalli, Mohitnagar, and Kahikuchi
Agr. XI (131)	Studies on placement and fractional application of fertilizers	Peechi
Agr. XIII (131)	Root studies of arecanut palms of different age and under different soil conditions	Vittal and Palode
Agr. XIV (131)	Crop weather study	Peechi, Palode, Hirehalli, Mohitnagar, Kahikuchi, and Vittal
Agr. XV (131)	Economics of arecanut cultivation	Vittal, Palode, Peechi, Hirehalli, Mohitnagar, and Kahikuchi
All India Co-ordinated Project		
Experiment 17	NPK experiment on high yielding variety of arecanut	Vittal, Hirehalli, Peechi, and Kahikuchi

SUMMARY

Thermophosphate and Suphala were superior to superphosphate, Factamfos, and Ultrafos in a laterite soil of Vittal in releasing available P_2O_5. All the P-fertilizers, at their highest doses, raised the available P-status of soil above 25 ppm P_2O_5, which is considered as the level of sufficiency. P-content of arecanut leaf, yield of ripe nuts, and nut number was not significantly affected by different levels of P-carriers. Among the green manure crops, *Pueraria javanica* gave the highest tonnage of green matter at Vittal and Mohitnagar, and *Centrocema pubescens* at Hirehalli. Nutrient removal studies indicated that a crop of *Pueraria* yielding 14.35 t green matter/ha, could supply the soil from its above-ground parts 99.33 kg N, 16.54 kg P_2O_5 and 59.06kg K_2O. The palms receiving inorganic fertilizers produced significantly more number of nodes. The treatment, organic manures and cultivation, produced more leaves. The pH of soil from inorganic fertilizer alone was lower than that of the treatment organic manure.

Work in progress

SCh. II (131). **Mobility and availability of applied phosphorus in soil profile**

(A. R. Mohapatra and N. T. Bhat)

The field experiment was laid out at Vittal in 1970 to assess the release of P from five P-fertilizers in soil. The treatments consisted of applying superphosphate, Factamfos, Suphala, and Thermophosphate at 40 and 60 kg P_2O_5/500 palms and Ultrafos at 80 and 120 kg/500 palms. The different P-fertilizers were applied to the palms in November. Soil and leaf samples were collected in March, June, and September and analysed for their P-content (Table 44).

Thermophosphate recorded the highest availability of P_2O_5 in March and September, whereas in June, Suphala at 60 kg P_2O_5/500 palms gave the highest release. Overall effects of different treatments were highly significant, and Thermophosphate and Suphala applied at 60 kg P_2O_5/500 palms were the most superior. Except for Ultrafos, all the carriers at 60 kg P_2O_5/500 palms showed significantly more soil available P_2O_5 than the 40 kg P_2O_5 dose. There was also a significant reduction of fluoride-extractable P in soil from March to September. When adjudged by the standard of 25ppm of P_2O_5 as the level of sufficiency in soil, all the five P-fertilizers applied at their high dose were equally good from the point of view of meeting the P-requirement of arecanut. P-content of leaf from different treatments were not statistically significant. Similarly, although yield of nuts and nut number from different treatments for 1970–71, 1971–72, and 1972–1973 significantly increased from one year to the other, the treatment differences were not statistically significant for each year. There was also an indication that the magnitude of differences of different treatments as regards yield was nearly constant over the years.

SCh. III (131). **Comparative study of different green manure and cover crops and their organic matter addition capacity**

(A. R. Mohapatra, M. Sannamarappa, R. N. Brahma, and N. T. Bhat)

The green matter yield of cover crops grown at Vittal, Hirehalli, and Mohitnagar during 1972 together with their nutrient removal values are presented in Table 45. At Vittal, *Pueraria javanica* gave the highest tonnage of green matter among the four different green manuring crops, although it did not differ significantly from others. The yield of green manure crops differed significantly at Hirehalli and Mohitnagar. At Hirehalli, *Centrocema pubescens* gave the highest yield of green matter, but it was not significantly more than that of *P. javanica*. At Mohitnagar, *P. javanica* yielded the maximum amount

Table 44. RELEASE OF AVAILABLE PHOSPHORUS FROM DIFFERENT PHOSPHATIC CARRIERS IN SOIL

(Mean values of P_2O_5 expressed in PPM)

Sl. No.	Treatment (Kg P_2O_5/500 palms)	Month			Mean
		March	June	September	
1	Superphosphate 40 kg	35 . 20	19 . 95	15 . 30	23 . 50
2	Superphosphate 60 kg	79 . 86	59 . 09	26 . 20	55 . 10
3	Factamfos 40 kg	27 . 60	17 . 07	11 . 00	18 . 60
4	Factamfos 60 kg	76 . 66	43 . 19	17 . 20	45 . 70
5	Suphala 40 kg	36 . 93	50 . 98	14 . 83	34 . 30
6	Suphala 60 kg	101 . 86	110 . 88	26 . 60	79 . 80
7	Thermophosphate 40 kg	69 . 60	63 . 69	24 . 71	52 . 70
8	Thermophosphate 60 kg	120 . 00	107 . 65	36 . 53	88 . 10
9	Ultrafos 80 kg	25 . 00	12 . 91	9 . 60	15 . 60
10	Ultrafos 120 kg	29 . 20	32 . 65	15 . 26	25 . 70
	Mean	60 . 20	51 . 80	19 . 70	

LSD (For months) 6 . 50**

LSD (For P-fertilizers) 19 . 90**

** Significant at 1% level of probability

Table 45. YIELD OF GREEN MATTER AND NUTRIENT REMOVAL VALUES FOR DIFFERENT GREEN MANURE CROPS

Name of the crop	Yield of green matter in 1972 (ton/ha)			Mean yield of green matter 1970–72 (ton/ha)	Moisture %	Nutrient composition (%)			Nutrient removal (kg/ha)		
	Vittal	Hirehalli	Mohitnagar			N	P	K	N	P	K
Calopogonium muconoides	15.02	1.48	8.21	7.14	78.37	2.63	0.23	2.80	40.50	3.46 (7.92)	43.12 (51.91) μ
Pueraria javanica	18.88	7.40	22.93	14.35	79.01	3.30	0.24	1.63	99.33	7.22 (16.54)	49.06 (59.06)
Stylosanthes gracilis	12.55	. .	14.48	12.81	79.40	2.42	0.23	1.63	63.64	5.91 (13.54)	42.87 (51.61)
Mimosa invisa	14.75	5.30	20.40	12.62	77.63	3.96	0.34	2.00	111.67	9.44 (21.62)	56.40 (67.90)
Sesbania speciosa	. .	4.10	3.69	5.18	77.50	2.70	0.17	1.12	31.32	1.97 (4.51)	12.99 (15.64)
Centrocema pubescens	. .	7.90	. .	6.90	75.20	2.54	0.24	1.75	43.43	4.02 (9.21)	29.92 (36.02)
Crotalaria anagyroides	. .	4.93	. .	3.39	78.30	2.81	0.27	2.12	20.51	1.97 (4.51)	15.47 (18.62)
LSD (P = 0.05)	21.8 NS	98.44 **	1.28 **								

** Significant at 1% level of probability

NS Not significant

μ Figures in parenthesis represent the oxide form of the nutrients

of green matter among the five green manuring crops grown there. The yield of green manure and cover crops raised at Hirehalli was low as compared to that at Vittal and Mohitnagar. In general *P. javanica* and *Mimosa invisa* were found to be the best green manure crops from the point of view of nutrient addition and yield of green matter.

SCh. V (131). **Studies on nutrient exhaustion by *Areca* palm**

(N. T. Bhat and A. R. Mohapatra)

No work was done during the period.

SCh. VI (131). **Composition changes in soil and plant by the continuous use of fertilizers, manures, and cultural practices**

(N. T. Bhat and A. R. Mohapatra)

This experiment with six treatments and four replications was planted at Vittal in 1969.

The second split dose of inorganic fertilizers was applied in February. The full dose of organic manure for the year, and half the dose of fertilizers were also added to the palms in the first week of November.

The soil and leaf samples data for 1972 (Table 46) showed that the treatments did not show any significant differences among themselves except for pH. The treatments receiving organic manures alone and organic manures + cultivation showed significantly higher pH than the treatments, inorganic fertilizers and inorganic fertilizers + cultivation. Similar results for soil pH were also recorded during 1973. Also in 1973, the surface soil contained significantly higher amount of organic carbon than the sub soil. The treatment organic manure + cultivation had significantly more carbon than the treatments inorganic fertilizers and inorganic fertilizers + cultivation. Total N, available N, available P_2O_5, and available K_2O were not also significantly affected by different treatments. Except for available K_2O, the surface soil contained more of these nutrients than the lower layer. The morphological data of plants collected in October 1972 showed that there was no significant difference among the treatments except for the number of nodes. Application of inorganic fertilizers alone produced the highest number of nodes. The morphological data collected in October 1973 also gave similar results. In addition, the treatments, organic manures and cultivation, significantly increased leaf number also (Table 47).

Table 46. MASS VALUE OF SOIL ANALYSIS DATA FOR 1

Sl. No.	Treatment	1972									
		pH		Organic carbon %		Available nutrients (ppm) N		P_2O_5		K_2O	
	Soil layer →	0-50 cm	50-100 cm	0-50 cm	50-100 cm	0-50 cm	50-100 cm	0-50 cm	50-100 cm	0-50 cm	50-100 cm
1	Application of organic manure alone	5.81	6.14	1.33	1.48	125.00	129.75	9.50	22.25	78.25	128 50
2	Application of inorganic fertilizers alone	5.70	5.53	1.22	1.18	118.00	138.50	6.25	12.75	104.25	102.25
3	Application of organic manures + inorganic fertilizers	5.66	5.99	1.35	1.12	147.25	140.50	15.50	20.00	192.50	148.50
4	Treatment 3 + cultivation	5.65	6.07	1.29	1.39	136.25	135.75	18.50	13.50	81.75	118.75
5	Treatment 1 + cultivation	5.65	6.13	1.30	1.12	139.50	130.75	6.25	12.00	59.00	103.25
6	Treatment 2 + cultivation	5.60	5.41	1.17	1.19	137.50	141.75	21.50	9.50	129.25	153.50
	C. V. (%)	4.74	3.19	16.87	16.65	12.37	10.99	96.90	47.07	560.02	46.59
	C. D. (P = 0.05)		0.28								

Note * Percentage values were transformed into angular values
Figures in parenthesis are actual percentage got after ret
C. D. are in angular values only

FOR 1972 AND 1973

1973											
pH		Organic carbon %		Total N %*		Available nutrients (ppm) N		P_2O_5		K_2O	
0–50 cm	50–100 cm	0–50 cm	50–100 cm	0–50 cm	50–100 cm	0–50 cm	50–100 cm	0–50 cm	50–100 cm	0–50 cm	50–100 cm
6.35	6.33	6.40 (1.25)	5.12 (0.79)	1.90 (0.11)	1.64 (0.08)	173.3	133.8	33.0	14.8	79.3	90.50
5.30	5.33	5.02 (0.77)	4.57 (0.63)	1.71 (0.09)	1 53 (0.07)	154.5	131.8	12.6	8.6	66.8	59.30
5.63	6.03	5.78 (1.00)	4.90 (0.73)	1.74 (0.09)	1.77 (0.10)	162.5	143.0	24.6	14.6	68.8	76.80
6.10	6.30	6.22 (1.02)	5.23 (0.83)	1.96 (0.12)	1.62 (0.08)	157.5	130.8	43.7	21.1	87.5	65.00
6.40	6.60	6.67 (1.40)	5.02 (0.79)	1.90 (0.11)	1.69 (0.09)	163.8	129.5	32.7	10.8	82.5	83.00
5.35	5.33	5.28 (0.85)	4.61 (0.65)	1.73 (0.09)	1.48 (0.07)	144.5	130.0	20.6	12.3	66.3	77.00
7.01	3.53	11.38	13.64	8.74	10.81	14.30	12.67	74.37	81.94	22.93	17.30
0.62	0.32	1.01	—	—	—	—	—	—	—	—	—

r values

t after retransformation

Table 47. EFFECT OF FERTILIZERS, MANURES, AND CULTIVATION ON MORPHOLOGICAL CHARACTERS (1972 AND 1973 DATA)

Sl. No.	Treatment	1972				1973			
		No. of leaves	Girth at collar (cm)	Total height (cm)	No. of nodes	No. of leaves	Girth at the last exposed nodes (cm)	Total height (cm)	No. of nodes
1	Application of organic manures alone	8.67	50.53	349.28	5.08	8.33	39.45	465.90	11.63
2	Application of inorganic fertilizers alone	8.35	61.00	388.53	8.25	7.75	37.78	506.40	15.13
3	Application of organic manures + inorganic fertilizers	8.68	53.52	377.85	6.83	8.23	38.72	503.30	13.67
4	Treatment 3 + cultivation	8.45	55.05	357.00	6.13	8.23	40.25	497.50	12.30
5	Treatment 1 + cultivation	8.45	48.47	226.83	4.95	8.42	38.60	472.50	11.10
6	Treatment 2 + cultivation	7.85	54.35	338.15	6.85	7.35	35.03	452.90	12.80
	C. V.%	4.88	10.61	8.95	16.90	4.61	7.13	6.38	10.88
	C. D.	. .	. .	. .	1.62	0.56	. .	. .	. .

Table 48. PROGRAMME OF WORK (SOIL CHEMISTRY) FOR 1974

Project No.	Name of the Project	Venue
SCh. II (131)	Mobility and availability of applied phosphorus in soil profile	Vittal
SCh. V (131)	Studies on nutrient exhaustion by *Areca* palm	Vittal and Mohitnagar
SCh. VI (131)	Studies on composition changes in soil and plant by the continuous use of fertilizers, manures, and cultural practices	Vittal
All India Co-ordinated Project		
Experiment 18	Analysis of soil and tissue samples collected from healthy and root (wilt) and yellow leaf affected tracts	Vittal and Kasaragod

BIOCHEMISTRY

Table 49. PROGRAMME OF WORK (BIOCHEMISTRY) FOR 1974

Project No.	Name of the Project	Venue
All India Co-ordinated Project		
Experiment 38	Biosynthesis of proteins, lipids, and carbohydrates and the quality of end products of coconut and arecanut	Kasaragod
Experiment 39	Protein and carbohydrate metabolism in relation to root (wilt) disease of coconut and yellow leaf disease of arecanut	Kayangulam

TECHNOLOGY

SUMMARY

Plant-scale trials showed that arecanut pulp could be used for producing wrapping paper in admixture with long fibred pulp. Two *ad hoc* schemes for developing industrial uses for *Areca* leaf sheath and alternate uses for arecanut are awaiting clearance.

Work in progress

Experiment 41. **Investigations on developing alternate uses for arecanut other than chewing**

(N. M. Nayar in co-operation with a number of private and public agencies)

Plant-scale trials were carried out at the Punalur Paper Mills Ltd., Punalur (Kerala State), on pulping of arecanut husk and using it for the production of kraft paper both alone and in combination with other pulps. The experiments indicated that (1) it was possible to pulp arecanut husk using 15.0–18.0% cooking chemicals (NaOH and Na_2S) at a temperature of 165°–170°C. The yield varied from 45–50%; (2) the pulp was short-fibred, the average fibre length being about 0.9 mm only; (3) the pulp was dark coloured, and contained specky matter and shives, which were difficult to eliminate; (4) the strength properties of paper made from 100% arecanut husk pulp were low, the maximum breaking strength and burst factor being in the range of 1600 m and 110, respectively; and (5) when arecanut pulp was blended with bamboo pulp (upto 25% arecanut pulp and the rest bamboo pulp), the kraft paper made out of it possessed as much, if not little more, breaking strength and burst factor than that made out of pure bamboo pulp.

They concluded that the pulp could at best be considered as raw material for producing lower grade wrapping paper in admixture with cleaner long-fibred pulp. The high cost of transporting husk to the factory and the high amount of cooking chemicals required for pulping are factors to be reckoned against it in exploiting it commercially.

Experiment 42. **Industrial uses of arecanut leaf sheath**

An *ad hoc* scheme submitted on this is awaiting ICAR's clearance.

Table 50. PROGRAMME OF WORK (TECHNOLOGY) FOR 1974

Project No.	Name of the Project	Venue
All India Co-ordinated Project		
Experiment 41	Investigations on the uses other than chewing of arecanut	Mysore and Lucknow
Experiment 42	Industrial use of arecanut leaf sheath	Vittal

PLANT PHYSIOLOGY

SUMMARY

Application of dolomitic limestone to the soil at Palode did not either improve the vigour or reduce foliar yellowing of diseased palms. Liming of acid soils of yellow leaf disease affected areas induced P-deficiency in french bean plants grown under green house conditions. Submergence of these soils for varying lengths of time reduced pH and slightly increased exchangeable Al at the end of 90 days. The variety Peechi 3 exhibited considerable tolerance to the disease and *Areca triandra* was completely free of disease. Sap inoculation did not produce disease symptoms on a number of test plants. TS of diseased roots showed abnormal arrangement of tissues and tyloses like structures in the xylem vessels. Bacterial streaming was also noticed in the roots of disease affected palms of Palode.

Work in progress

Phy. I (131). **Yellow leaf disease of arecanut palms**

(T. S. S. Rawther, P. Shanta, A. R. Mohapatra, C. K. Mathai, N. T. Bhat, K. J. Abraham, and V. G. Lilly)

A working group consisting of 22 scientists of the Institute who are associated with the disease was formed and it met twice in the year. It resolved to take up the work under a series of time-targeted experiments. The summary of the work done during the year is given below:

1. Leaf analysis revealed that N, K, Ca, and Mn contents of healthy palms were higher than those of diseased palms. On the other hand, palms from the healthy locality showed lower values for P, Mg, and Bo as compared to diseased samples (Table 51). Zn and Al content of healthy and diseased palms did not show any appreciable difference.

Table 51. Mineral nutrient content of arecanut leaf from healthy and yellow leaf disease affected areas

Element	Healthy area (Vittal)	Diseased area (Palode)	
		Relatively healthy palms	Diseased palms
Major elements (%)			
Nitrogen	1.51	1.37	1.06
Phosphorus	0.21	0.35	0.34
Potassium	1.02	1.59	0.88
Calcium	1.14	0.72	0.64
Magnesium	0.26	0.60	0.75
Minor elements (ppm)			
Iron	440	476	328
Manganese	190	161	76
Boron	5	8	10
Copper	5	2	5
Zinc	38	33	34
Aluminium	420	442	403

2. Liming of acid soils collected from yellow leaf disease affected areas of south Kerala induced Mg deficiency in french bean plants under green house conditions. Submerging these soils for varying lengths of time reduced the pH and slightly increased the exchangeable Al at the end of 90 days. Arecanut root was found to be a suitable material for analysis to diagnose Al toxicity in this crop.

Liming acid soils on the availability of nutrients to french bean plants. A pot culture study was conducted on 13 acid soils collected from yellow leaf disease affected areas of Trivandrum district (Kerala State) to find out the effect of liming on growth and nutrient composition of french bean (*Phaseolus vulgaris* L) which was used as a test crop under green house conditions. Soil analysis showed that they were low in major and micronutrients excepting N and available Fe. The pH of these soils varied from 4.4 to 5.2 and clay from 11 to 31%. Average values of Al extracted by I *N* KCl and I *N* NH_4OAc (pH 4.8) were 60 and 167 ppm, respectively.

The two treatments, one receiving lime and the other without it, were replicated twice. Lime was added as $CaCO_3$ to one set of soils at the rate of half their lime requirements. A basal dose of NPK was added to both the treatments at the rate of 31.25 mg N as ammonium sulphate, 12.50 mg P_2O_5 as potassium dihydrogen orthophosphate, and 31.25 mg K_2O as potassium chloride. Each pot contained 0.5 kg soil and two french bean plants. In the initial stages of growth, the plants receiving lime were better in their growth than those without it. Yellowing of leaves was first observed on the older leaves of limed plants during flowering and these symptoms appeared in plants without lime. Foliar application of 2% $MgSO_4$ did not reduce yellowing. The plants were then harvested and analysed for their nutrient contents.

The data (Table 52) showed that application of lime depressed the N, P, K, Al, and Mn content of french bean plants. It reduced the KCl extractable Al content of soils to a safe limit. Further, the total uptake and percentage of Ca was increased in plants. Phosphorus content of plants from both the treatments was very low resulting in foliar deficiency of this nutrient. The Mg content of plants of both lime and control treatments was also low.

3. Effect of submergence on pH and exchangeable Al content of yellow leaf disease affected soils. This was studied in the 13 acid soils used in the previous trial. Soils were submerged in 100 ml beakers for 15, 30, 60, and 90 days. Water level was maintained at 5 mm above the surface of soil. Most of the soils (Table 53) showed increase in their pH values during the first 30 days of submergence which later decreased at the end of 90 days. The KCl extractable Al also showed a similar trend.

4. Diagnostic evaluation of plant material for screening Al toxicity in arecanut. Root and leaf samples from yellow leaf disease affected gardens of

Table 52. EFFECT OF LIMING ACID SOILS ON THE CHEMICAL COMPOSITION OF FRENCH BEAN PLANTS

	Dry matter of plant top (g/pot)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Fe/Mn ratio	Al (ppm)
Soil alone	1.800	4.350 (76.890)*	0.067 (1.150)*	1.800 (31.910)*	0.758 (14.070)*	0.454 (8.210)*	223.660 (390.420) μ	149.230 (266.290) μ	1.520	221.150 (392.420) μ
Soil + Lime	0.050	3.400 (68.850)*	0.044 (0.904)*	1.430 (29.230)*	1.760 (36.230)*	0.464 (9.640)*	164.400 (330.160) μ	70.760 (143.830) μ	2.410	163.420 (336.330) μ

* Figures in parenthesis represent total uptake in mg/pot

μ Figures in parenthesis represent total uptake in g/pot

Table 53. pH AND KCl EXTRACTABLE Al FRACTION OF SOILS SUBJECTED TO DIFFERENT PERIODS OF SUBMERGENCE

Soil No.	Before submergence			After submergence							
				15 days		30 days		60 days		90 days	
	pH	KCl extractable Al (ppm)	NH_4OAc extractable Al (ppm)	pH	KCl extractable Al (ppm)	pH	KCl extractable Al (ppm)	pH	KCl extractable Al (ppm)	pH	KCl extractable Al (ppm)
1	5.15	63.33	250.00	5.55	10.00	5.40	21.25	4.40	85.00	4.30	88.25
2	4.95	125.00	246.60	5.55	36.50	5.45	70.25	4.30	138.75	4.20	140.30
3	4.95	65.00	133.30	5.75	4.75	5.35	30.75	4.05	87.50	3.90	78.75
4	5.10	30.00	110.00	6.35	1.75	6.15	2.50	4.45	27.50	4.30	37.50
5	4.40	125.00	200.80	6.55	54.75	6.45	64.25	5.65	86.25	5.10	121.25
6	4.90	46.66	150.00	6.55	2.50	5.80	4.25	4.30	67.50	4.15	65.00
7	5.00	38.33	110.00	6.25	1.75	5.30	17.50	4.40	52.50	4.35	40.00
8	5.00	30.00	145.80	6.30	1.75	5.80	2.50	4.20	72.50	4.15	66.25
9	5.20	118.33	285.00	5.95	50.00	5.70	48.75	4 40	130.00	4.15	126.25
10	4.80	58.33	112.50	5.95	6.75	5.50	23.25	4.30	70.00	3.85	81.25
11	5.20	33.33	137.50	6.15	1.75	5.55	14.25	4.15	56.25	4.10	60.00
12	5.10	36.66	88.30	5.80	25.00	5.30	34.00	4.05	62.50	3.95	126.25
13	5.40	10.00	208.30	6.40	2.50	6.10	2.50	5.20	3.50	5.10	2.50

Palode (Trivandrum) and Sullia (South Kanara), and disease free gardens of Vittal (South Kanara) were chemically analysed in an attempt to relate them with the incidence of the disease (Table 54). Ten samples were collected from each category. The roots of diseased palms of Sullia and Palode contained more Al and less NPK than those of healthy plants. Leaf analysis did not bring out any difference for NPK or Al between healthy and disease samples from any of the places. It appeared that root analysis was a more dependable diagnostic criteria for assessing Al toxicity in arecanut.

4. A field experiment using high dose of Ca was laid out at Palode in December 1970. The treatments were (i) no lime, (ii) dolomite @ 4.0 kg per palm per year, and (iii) dolomite @ 8.0 kg per palm per year. The palms were indexed for the disease before the treatment and afterwards at half-yearly intervals. There was no significant change in the disease condition of the palms.

5. The palms of the varietal collection at Palode were indexed for the disease. The results showed that the differences between varieties were highly significant for (i) intensity of the disease, (ii) number of nuts produced per palm, and (iii) weight of nuts produced. The varieties Paharpur, Kottakal, and Nathua yielded the best. Vittal 4 and 5 were the most susceptible to the disease. Peechi 3 was the poorest yielder, but the intensity of the disease was very low in it. The related wild palm *Areca triandra* was also free of the disease.

6. Several varieties of chillies, *Nicotiana tabacum*, beans, *Chenopodium amaranticolor*, *Amaranthus* sp., *Gomphrena*, *Jatropha*, *Manihot*, and *Canavalis* were inoculated with crude leaf sap of diseased palms. None of the indicator plants showed any disease symptoms.

Some other indicator plants like maize, cotton, rice, tobacco, and brinjal were grown *in situ* and also in pots containing infested soil. The plants have not so far shown any disease symptoms.

7. Anatomical studies of the roots of diseased palms were made. In all cases the tender roots showed normal arrangements of tissues while middle aged and old roots showed proliferation of phloem extending up to the metaxylem. Tyloses-like structures were also seen in protoxylem and metaxylem vessels.

8. Observations on bacterial streaming were carried out on 550 healthy roots of Vittal and Mohitnagar. All the samples from Vittal were free of streaming, while 20% of the samples from Mohitnagar exhibited the phenomenon. At the same time, 70% of 250 diseased samples collected from Palode showed bacterial streaming.

Table 54. Chemical composition of leaf and roots from healthy and diseased arecanut gardens

Description of sample	N (%)	P (%)	K (%)	Al (ppm)
Root from healthy palms of disease free garden (Sullia, South Kanara)	0.560	0.040	1.510	2250
Root from healthy palms of disease affected garden (Sullia, South Kanara)	0.532	0.020	0.860	3600
Root from diseased palms of disease affected garden (Sullia, South Kanara)	0.392	0.025	0.900	3775
Leaf from healthy palms of disease free garden (Sullia, South Kanara)	2.268	0.140	1.110	190
Leaf from healthy palms of disease affected garden (Sullia, South Kanara)	2.408	0.210	1.020	100
Leaf from diseased palms of disease affected garden (Sullia, South Kanara)	1.302	0.143	1.502	75
Root from healthy palms of disease affected garden (Palode, Trivandrum)	0.605	0.026	0.676	2550
Root from diseased palms of disease affected garden (Palode, Trivandrum)	0.694	0.034	0.624	9350
Leaf from healthy palms of disease affected garden (Palode, Trivandrum)	1.920	0.131	1.057	66
Leaf from diseased palms of disease affected garden (Palode, Trivandrum)	1.808	0.134	1.374	144
Root from healthy palms of disease free garden (Vittal, South Kanara)	0.666	0.075	2.242	925
Leaf from healthy palms of disease free garden (Vittal, South Kanara)	1.946	0.150	1.065	235

*** Results are mean of ten samples expressed on oven dry basis**

Table 55. PROGRAMME OF WORK (PLANT PHYSIOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Phy. I (131)	Yellow leaf disease of arecanut	Vittal, Kayangulam, and Palode
Phy. II (131)	Physiology of growth and development of arecanut palm	Vittal

PLANT PATHOLOGY

SUMMARY

The fungus *Ganoderma lucidum* was observed on 57% of the infected roots and 40% of the roots showed outgrowths in xylem vessels. The fungus could be easily isolated from the infected roots by adding 8 ppm Benlate and 16 ppm Difolatan to the basal medium. The fungus *Colletotrichum* was associated with 75% of the fallen buttons and 30% of the buttons collected from the infected inflorescence. The pathogen was observed to enter the inflorescence mainly during its male phase. In *in vitro* studies, Captan, Thiram, and Leytosol were fungicidal, while Benlate was fungistatic against the fungus.

Work in progress

Path. III (131). **Investigations on 'Anabe'**

(R. Radhakrishnan Nair and N. Saraswathi)

Symptomatological studies showed the presence of the fungus in 57% of the infected roots. Ten roots each of 15 infected palms, were observed and xylem outgrowths were noticed in 40% of them.

By adding 8 ppm Benlate and 16 ppm Difolatan to the basal medium, the fungus could be isolated from infected roots with minimum contamination from other fast growing fungi. The susceptibility of 30 common *Areca* weeds to the fungus was studied and root decaying, wilting, and drying of leaves were seen on two of them, *viz.*, *Phyllanthus* sp. and *Acanthospermum* sp.

Path. VIII (131). **Possible role of the fungus *Gloeosporium* on die-back of *Areca* inflorescence**

(N. Saraswathi and R. Radhakrishnan Nair)

The fungus responsible for the malady has been identified as *Colletotrichum* stage of *Glomerella cingulata* by CMI, Kew, UK, and not *Gloeosporium* as it was originally thought. Fresh cultures are being prepared to be sent to CMI for confirmation.

The fungus could be isolated from 75% of the shed buttons collected from soil, while those collected on polythene sheets without the contact of soil showed only 41% fungal infection and those from the bunch directly in polythene bags only 30% infection.

Different media were tried to isolate all possible micro-organisms associated with the disease. No bacterium could be isolated while a few shed buttons showed the presence of *Curvularia* sp. and *Fusarium* sp.

Areca inflorescences were covered with cloth bags at three stages of development to determine the stage at which the infection takes place. The stages were (1) female flowers open, (2) male phase running but female phase not started, and (3) spathe not opened. Shedding of buttons and drying of inflorescence were not observed in treatment (3) whereas treatment (2) showed a heavy incidence of both. As in the control, treatment (1) also showed about 50% shed buttons with fungal infection. From these observations, it was evident that the fungal infection took place mainly during the male phase. The fungus may be gaining entry through the natural wounds caused by the shed male flowers. The severe shedding of buttons and drying of inflorescence in treatment (2) might be resulting from the lack of pollination of buttons which could also enhance the drying of inflorescences.

An *in vitro* fungicidal trial was carried out against the fungus using poisoned bait technique on oats-agar medium and inoculated at room temperature (26–30°C). Thirteen fungicides were tried. The data (Table 56) showed that Leytosol and the organic fungicides, Captan and Thiram, were fungicidal, while Benlate was fungistatic against the fungus. A field trial using the screened fungicides is in progress now.

Table 56. Mean colony diameter of *Colletotrichum* ten days after inoculation

Sl. No.	Fungicide	Concentration (in ppm)	Colony diameter after 10 days (in mm)	After-growth
1	Aureofungin sol	100	30	—
2	Benlate	1000	—	Fungistatic
3	Bordeaux Mixture	10000	19	—
4	Captan	2500	—	Fungicidal
5	Ceresan wet	1000	19	—
6	Difolatan	1000	44	—
7	Dithane M-45	2000	70	—
8	Dithane Z-78	2000	64	—
9	Fytolan	2500	64	—
10	Hinosan	1000	23	—
11	Leytosol	2500	—	Fungicidal
12	Thiram	2500	—	Fungicidal
13	Vitavax	1000	35	—
14	Control	....	90	—

Table 57. PROGRAMME OF WORK (PLANT PATHOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Path. III (131)	Investigations on 'anabe'	Vittal and Hirehalli
Path. V (131)	Survey for assessing crop losses due to diseases	Vittal, Hirehalli, Kahikuchi and Peechi
Path. VI (131)	Crown rot disease in Assam	Kahikuchi and Vittal
Path. VIII (131)	Possible role of the fungus *Gloeosporium* on the die-back of *Areca* inflorescence	Vittal
All India Co-ordinated Project		
Experiment 19	Crown rot of coconut and arecanut	Kayangulam

ENTOMOLOGY

SUMMARY

Biology of *Stethorus* sp. the predatory beetle of red mite was worked out. Dimethoate (Rogor) 5% granules applied at 30 kg/ha was found to be the best insecticide against white grub in a field experiment. So far, 20 pests of cacao have been collected. Of these, *Lymantria obfuscata* is reported for first time from South India. Phorate, thiodemeton, and carbaryl were significantly effective in controlling the spindle bug *Carvalhoia arecae*.

Work in progress

Ent. I (131). Bionomics and control of mites

(Mariamma Daniel and T. Prem Kumar)

Biology of *Stethorus* sp., the predatory beetle of red mite *Raoiella indica*, was worked out. The beetle required 13–15 days to complete its life cycle. The incubation period of the eggs was about 3½–4 days. There were four larval instars and they were completed in 5-6 days. Pupation period lasted 4½–5 days. Both adults and grubs of this beetle feed on red mites and their eggs. An adult beetle consumes about 2.4–6.5 mites/hr.

Studies on biological control of mites using the exotic predatory mite *Phytoseiulus persimilis* were given up as the predator could not adapt itself to the local climatic conditions.

Ent. III (131). Biology and control of white grub *Leucopholis burmeisteri*

(T. Prem Kumar and Mariamma Daniel)

1. Trial with granular systemic insecticides and chlordane

The field experiment was laid out in November 1972 at Polya (South Kanara district, Karnataka) in a white grub infested garden to test the efficiency of five granular insecticides and one dust formulation. There were seven treatments with four replications. The net plot size was 50 sq.m. The insecticides and their dosages were (i) Phorate (Thimet 10% Cyanamid)-15 kg/ha, (ii) Thiodemeton (Solvirex 5% Sandoz) - 30 kg/ha, (iii) Thiodemeton (Disyston 5% Bayer)- 30 kg/ha, (iv) Dimethoate (Rogor 5% Rallis) - 30 kg/ha, (v) Carbofuran (Furadan 3% Rallis) - 45 kg/ha, (vi) Chlordane - 30 kg/ha, and (vii) control.

Pre treatment observations were recorded on three samples collected from pits of size 50 cm^3. The monthly count of grubs during the first year of the experiment showed that Rogor was the most effective of all the insecticides tried. Further, all the insecticides treated plots gave lower number of grubs than the control plot. The third dose of insecticides was given in November. The study is continuing.

2. Trial with contact insecticides

A field experiment was laid out for this at Mithur (South Kanara district, Karnataka) in December 1973. The insecticides and their doses were (i) BHC–60, 90 and 120 kg/ha, (ii) Aldrin–60, 90 and 120 kg/ha, (iii) Chlordane–60, 90 and 120 kg/ha, (iv) Heptachlor–60, 90 and 120 kg/ha, (v) Ekalux–60, 90 and 120 kg/ha, and (vi) Control.

There were three replications and the plot size was 25 sq.m. The trial is in progress.

3. Trial with oil cakes

Another experiment was laid out at Mithur using two oil cakes applied at two doses each. The treatments were (i) Neem cake and pongamia cake – 1000 and 2000 kg/ha, each, and (ii) Control.

The experiment was initiated in September 1973. It has four replications and the plot size is 25 sq.m. Pre treatment observations were taken from three sample pits of size 50 cm^3. The oil cakes were applied and admixed to the soil. Monthly observations are being taken and the experiment is in progress.

4. Studies with the nematode DD-136 *Neoaplectana carpocapsae*

The culture of DD-136 was best maintained in the media peptone-agar and dog biscuit. Since the digestive system of the white grub contains soil and other foreign materials which can contaminate the culture, the grub was not found to be a suitable material for multiplication of the nematodes.

Topical application with the nematode suspension containing 60–100 nematodes killed early instar grubs in five days. Trials were also conducted in soil in which nematode suspensions were poured at three doses, *viz.*, 150–200, 300–400, and 600–800 nematodes, into a bottle containing one grub and 250 ml soil. Arecanut roots were given as the feeding material. The treatment containing 600–800 nematodes killed the grubs in 23 days. The grubs were not killed from the other treatments but the adults emerging from them showed malformed wings.

The search for *Campsomeriella collaris* did not reveal its presence in this area.

Ent. VII (131). Storage pests of arecanut

(T. Prem Kumar and Mariamma Daniel)

Preliminary studies revealed that the beetle *Araecerus fasciculatus* was the most common pest in the Station godown and that it preferred husked arecanut. Unhusked nuts with intact calyx were not affected after one year of storage while those without calyx were infested within six months.

Samples of stored arecanut were collected at bimonthly intervals from godowns of Mangalore for the study of damage caused by the storage pests. Information on capacity of the godown, quantity of arecanut stored, period of storage, moisture content of arecanut, physical condition of the godown, and nature and type of prophylactic measures practised were also obtained. The survey revealed that *Araecerus fasciculatus*, *Coccotrypes carpophagus*,

Lasioderma serricorne, *Tribolium castaneum*, and *Corcyra cephalonica* were the common storage pests.

The effect of moisture on the susceptibility of arecanut to infestation by *Araecerus fasciculatus* showed that samples containing only 3–5% moisture were not damaged. When the moisture content was increased to 6–10% there was 6–8% infestation in 45 days.

In addition to the above pests, the fungi *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Eurotium* sp., *Curvularia* sp., *Trichoderma* sp., *Rhizopus* sp., *Mucor* sp., and *Penicillium* sp., were also isolated from the samples.

Ent. VIII (299). **Survey of the pests of cacao in India**

(T. Prem Kumar)

Out of 20 pests collected so far, six were identified by the Commonwealth Institute of Entomology, London. They were a leaf feeding beetle *Popillia complanata* (Scarabaeidae), a stem boring beetle, *Sinoxylon* sp. (Bostrychidae), leaf feeding caterpillars *Lymantria obfuscata* (Lymantridae), *Dasychira mendosa* (Lymantridae), *Hyposidra talaca* (Geometridae), and a leaf webber *Adoxophyes privatana* (Tortricidae). The other pests collected were *Achoea janata*, *Euproctis* sp., *Diacrisia obliqua*, *Pericallia ricini*, *Monolepta longitarsus*, *Zeuzera coffeae*, *Prodenia litura*, mealy bugs, thrips, and aphids. Of these, the leaf feeding caterpillars *Lymantria obfuscata*, *Dasychira mendosa*, and the beetle *Popillia complanata* were observed in cacao plantations throughout the year.

Consumption index of the leaf feeding caterpillars are now being studied to assess the seriousness of the damage caused by the caterpillars.

Aspergillus flavus, which is known to infect a wide range of insects, was found to be pathogenic to *Lymantria obfuscata* also. The affected caterpillar developed yellowish white patches on the body, became sluggish, and then stopped feeding altogether. In advanced stages of infection, whitish and greenish olive coloured conidiophores of the fungus covered the entire body of the caterpillar which became shrunken, wrinkled, and mummified.

Another fungus yet to be identified was also found to be pathogenic to *Lymantria obfuscata*. The entire body of the infected caterpillar was covered with whitish mycelia.

The effect of three antifeedant chemicals triphenyl tin acetate (Brestan 60W), triphenyl tin chloride (Brestanol 40W), and Ac 24055 was studied on two leaf eating caterpillars *Lymantria obfuscata* and *Pericallia ricini*. The concentrations tried were 0.0125, 0.025, 0.05, 0.1, and 0.2%. For the trials fourth instar caterpillars were used. There were six treatments including control and four replications. Leaf bits were preweighed, treated with chemicals at different concentrations, and air-dried. They were then placed in petri

dishes over a wet layer of cotton and filter paper. Four caterpillars were released for 60 hr in one petri dish over the treated leaves. The control consisted of leaves sprayed with water. The study is in progress.

Table 58. PROGRAMME OF WORK (ENTOMOLOGY) FOR 1974

Project No.	Name of the Project	Venue
Ent. I (131)	Bionomics and control of mites	Vittal and Peechi
Ent. III (131)	Biology and control of white grub (*Leucopholis burmeisteri*)	Vittal and Hirehalli
Ent. V (131)	Bionomics and control of spindle bug (*Carvalhoia arecae*)	Kayangulam and Palode
Ent. VI (131)	Survey for assessing crop losses due to pests (a) mites, (b) spindle bug, (c) inflorescence caterpillar, and (d) root grub	Vittal, Palode, Hirehalli, Peechi, and Mohitnagar
Ent. VII (131)	Storage pests of arecanut	Vittal
Ent. VIII (299)	Survey of the pests of cacao in India	Vittal

CO-ORDINATING CENTRES UNDER THE ALL INDIA CO-ORDINATED COCONUT AND ARECANUT IMPROVEMENT PROJECT

The All India Co-ordinated Coconut and Arecanut Improvement Project which has its headquarters at Kasaragod is in operation at the following centres, besides the CPCRI and its Regional and Substations.

Andhra Pradesh Agricultural University

Coconut Research Station, Ambajipeta

Pathology Laboratory, Razole

Gujarat Agricultural University, Ahamedabad

Plantation Crops Research Station, Mahua

Kerala Agricultural University, Trichur

Central Coconut Research Station, Nileswar

Konkan Krishi Vidya Peeth, Dapoli

Arecanut Research Station, Shriwardhan

Regional Coconut Research Station, Ratnagiri

Tamil Nadu Agricultural University, Coimbatore

Department of Agricultural Botany, Coimbatore

Pathology Laboratory, Muthupet

Regional Coconut Research Station, Yeppankulam

A brief summary of the work carried out at these centres is presented in the following paragraphs :

COCONUT

Cross combinations of Talls with different Dwarfs are being attempted at Ambajipeta. Twentythree exotic and indigenous cultivars are being studied for selection and hybridisation.

Investigations on the etiology and epidemiology of the 'Tatipaka' disease of coconut to work out suitable control measures are in progress at Razole.

NPK fertilizer trials on different soil types on ordinary Tall variety are in progress at Mahua.

Different cross combinations involving Dwarfs are being effected at Nileswar.

The germplasm collection at Ratnagiri consists of 34 cultivars. In the yield trials Laccadive Ordinary, Gangabondam, Philippines, Fiji, and T × D performed better than WCT. Crossing work involving promising varieties is in progress.

Trials on promising seed material laid out at Coimbatore with ten cultivars revealed that D × T is the most promising one.

The Thanjavur wilt disease is being investigated at Muthupet. Twenty isolates of Basidiomycetous fungi are maintained, and pathogenicity tests with five of these were continued on seedlings under pot culture conditions. High temperature with low rainfall during the months of May-July was found to be conducive to the disease. Varieties resistant to the disease are being screened.

At Veppankulam, manuring with NPK fertilizers at 340 g N, 227 g P_2O_5, and 454 g K_2O per palm per year resulted in an increase of 393.2% more yield than control. Palms planted at a depth of 60 cm registered the highest yield increase of 31.4% over those planted at the surface (30 cm). Palms planted at a spacing of 9.1 m × 9.1 m gave 20% more yield than those at 6.1 m × 6.1 m.

GENETICS

SUMMARY

Thirty seven accessions were added to the collection. A comparative yield trial has been laid out with 16 collections which had been assessed to be promising in the different cashew research centres of the country. Floral biology studies showed that the number of bisexual flowers in a panicle varied from 0 to 74 and male flowers from 106 to 1380. The ratio of male flowers to hermaphrodite flowers varied from 13-550 to 1 and fruit set from 2 to 21%. It took 52-122 days to complete male flowering in a panicle and 1-105 days to complete bisexual flowering. Among six hormones studied, 2, 4-D improved the fruit setting most.

Work in progress

Gen. I (176) and Experiment 1 & 3. **Collection, maintenance, and evaluation of germplasm**

(K. N. Murthy, N. M. Nayar, and P. M. Kumaran)

During the year, 37 accessions were added to the existing collection of 162 types, thus bringing the total to 199 accessions.

Germination pattern was studied in 162 accessions. The number of days taken to start germination varied from 10–24 days, the number of days taken to complete germination from 17–40 days and germination percentage from 15–100%.

Observations on early flowering and fruitset were taken on the accessions transplanted during the previous year. Out of the 162 varieties planted, 22 collections flowered and 15 set fruits. These include 13 accessions originating from Vridhachalam (Tamil Nadu) and nine from Vengurla (Maharashtra). In the comparative yield trial with 16 varieties, four from Vridhachalam, two from Bapatla and one each from Anakkayam and Vengurla flowered during the year.

Gen. II (176) **Varietal improvement on cashew**

(1) **Experiment 22. Floral biology**

(K. N. Murthy, N. M. Nayar, and P. M. Kumaran)

Observations were made on the time required to complete flowering in a panicle, number of male and bisexual flowers, length of flowering phase, and effect of selfing on fruit-set. In a panicle, the number of bisexual flowers varied from 0 to 74 and male flowers from 106 to 1380. The ratio of male flowers to hermaphrodite flowers ranged from 13–550 to 1.

Data gathered in 50 panicles (5 panicles x 10 trees) under natural conditions and in another 50 panicles of the same trees (5 panicles each), where male flowers were removed soon after their opening, revealed wide variations between the two groups in percentage of nuts set 2–10% under natural conditions and 4–21% when male flowers were removed. The time taken to complete flowering in a panicle ranged from 52 to 122 days, the time taken to complete male flowering from 52 to 122 days, and the time taken to complete bisexual flowering from 1 to 105 days. The overlapping of male and bisexual flowers took place from 1 to 105 days (data from ten panicles each from ten trees).

The period of retention of male flowers within a panicle was studied in 50 panicles (5 panicles x 10 trees). For this, flowers which opened on a particular day were retained on the panicles and all the remaining buds were

removed. It showed that the male flower will remain in a panicle for 2–10 days.

Effect of selfing on fruit set was observed in 50 panicles (5 panicles x 10 trees). Before the flowers opened, the panicles were covered with paper bags and muslin cloth bags. None of the panicles set any fruits.

Studies were initiated to find out the effect of six hormones (GA, NAA, IAA, IBA, 2, 4-D, and Planofix (May & Baker) on fruit set. They were sprayed on inflorescences at different concentrations and at different stage of development to determine the tolerance dosages. 2, 4-D in high, medium, and low concentrations and when sprayed at intervals when about 25, 50, and 75% male flowers had opened and also on panicles with both male and bisexual flowers opened, gave higher fruit set (13–110% over control – no hormone spray). The hormones IAA, NAA, Planofix, and IBA also produced better fruit set than control when sprayed at low and medium doses in the early and later stages of inflorescence (fruit set over control : IAA, 14–26%; NAA, 50–300%; Planofix 19–100%, and IBA,75–313%.)

(2) Experiment 2. Standardisation of seedling selection methods

(P. M. Kumaran and K. N. Murthy)

Correlations between seedling characters and yield attributes will be determined so that this information can be used during the seedling stages to identify potentially high yielding trees.

One hundred seeds each of 44 varieties were sown in polythene bags after recording their nut characters. Later, they were observed for germination and several morphological characters of seedlings. These seedlings will be transplanted at the Cashew Seed Farm, Shantigodu (Puttur) about 23 km from Vittal. Later correlations will be worked out between the performance of yielding trees and their seedling characters.

(3) Experiment 4. Hybridisation and selection

This will be taken up at a later period.

Gen. III (176) and Experiment 5. **Propagation studies**

(P. M. Kumaran and K. N. Murthy)

Work was initiated to determine the best method of vegetative propagation in Cashew. Air layering, veneer grafting, and patch budding were being evaluated. The heavy casualty of layers was apparently due to their being kept on the mother trees for much longer time–up to 90 days–than is required. It is now proposed to sever the layers from their trees after 60 days.

AGRONOMY

SUMMARY

An NPK fertilizer experiment on bearing trees has shown that the main effect of N was significant for both the number and weight of nuts. For both these characters, the N_2 level (300 g N per tree) gave the maximum response.

Work in progress

Agr. I (176) and Experiment 7. **NPK fertilizer experiment** (Sr. Res. Asst., Kasaragod)

An experiment on bearing trees (air layers and seedlings separately) is in progress at the Kerala Govt. Cashew Plantations, Periye, on a 3^3 factorial design with partial confounding of higher order interactions. The treatments consist of all combinations of three levels each of N (100, 300, 500 g/tree), P (75, 150, 225 g/tree), and K (100, 300, 500 g/tree) using urea, superphosphate, and muriate of potash as sources. There are two replications for seedling trees and one for air layers with each plot comprising nine trees (eight years old). The fertilizers were applied in August.

The yield data revealed that in the case of seedlings the main effect of N was significant for both the number and weight of nuts harvested. For both these characters, N_2 gave the highest response (1.58 kg yield) followed by N_3 (1.36 kg) and N_1 (0.87 kg), both N_2 and N_3 being significantly superior to N_1. In the case of air layers, none of the main effects and first order interactions showed any significance. The manuring for the second season was done in September.

Agr. I (176) and Experiment 6 & 7. **Foliar application of urea in combination with pesticides**

(M. C. Nambiar, Sr. Res. Asst., (Kasaragod), G. B. Pillai, and K. K. N. Nambiar)

Earlier studies had shown that nutritional imbalance, physiological factors, and insect attack are mainly responsible for immature fruit drop in cashew. A field trial on the foliar application of urea in combination with pesticides has been laid out at the Kerala Govt. Cashew Plantations, Periye. Two concentrations of urea, 10% and 15% individually and in combination with endosulfan at 0.1% applied as low volume spray, are being tried. There are 13 treatments and four replications with a plot size of six trees per treatment. The trials are continuing.

Agr. I (176) and Experiment 6 & 7. **Nutritional requirements**

This work will be taken up at a later period.

Agr. VI (176) and Experiment 8. **Pruning trials**

This will be worked out at a later period.

PLANT PATHOLOGY

SUMMARY

Inoculation studies showed that inflorescence blight was caused by the tea mosquito *Helopeltis antonii* and that the fungi found associated with the blighted inflorescences were only secondary saprophytic colonizers.

Work in progress

Path. I (176) and Experiment 34. **Inflorescence blight**
(K. K. N. Nambiar, Y. R. Sarma, and G. B. Pillai)

Inoculation trials were carried out in the field under controlled conditions to determine the relative roles played by the tea mosquito *Helopeltis antonii*, the fungus *Gloeosporium mangiferae*, and a non-sporulating fungus in the incidence of this disease. Healthy and mechanically injured inflorescences were sprayed with mycelial or spore suspension of fungi isolated from blighted inflorescences and covered with muslin cloth bags. Healthy inflorescences were also allowed to be infested with tea mosquito for 24 hr. The results obtained from different treatments are summarised in Table 59.

Table 59. Incidence of inflorescence blight of cashew on inoculation with tea mosquito and fungi

Sl. No.	Treatments	No. of inflorescences treated	No. of inflorescences affected
1	Caging the inflorescence with *H. antonii* alone	20	20
2	Caging the inflorescence with *H. antonii* after inoculating with fungus		
	i) *G. mangiferae*	20	20
	ii) Non-sporulating fungus	20	20
3	Inoculating with fungus alone		
	i) *G. mangiferae*	20	0
	ii) Non-sporulating fungus	20	0
4	Inoculation of injured inflorescence with fungus		
	i) *G. mangiferae*	20	0
	ii) Non-sporulating fungus	20	0
5	Caging fungicide-treated inflorescence with *H. antonii*	10	10
6	Caging insecticide treated inflorescence with *H. antonii*	20	0
7	Control – inflorescence caged	20	0
8	Control – injured inflorescence caged	20	0
9	Control – inflorescence without caging	20	18

The data showed that tea mosquito was primarily responsible for the incidence of blight and that fungi found associated with the blighted inflorescences were only secondary saprophytic colonizers. In the light of this finding, it is recommended that the fungicide could be eliminated from the spray schedule for the control of the malady.

Chemical control trials against the blight showed that endosulfan at 0.05%, when applied twice as high volume spray at the time of emergence of panicles and at fruit set, was effective in reducing the blight incidence. The treated plots yielded 2.03 Kg nuts per tree as against 1.21 Kg in the untreated control.

ENTOMOLOGY

SUMMARY

Spraying with endosulfan 0.05% was effective in reducing the blight. Infestation by tea mosquito, flower-thrips and fruit borer accounted for nearly 30% immature fruit drop. Biology of tea mosquito *(Helopeltis antonii)*, stem borer *(Plocaederus ferrugineus)* and defoliator *(Metanastria hyrtaca)* were worked out.

Work in progress

Ent. I (176) and Experiment 37. **Studies on the biology and bionomics of insect pests**

(G. B. Pillai and V. A. Abraham)

The tea mosquito *H. antonii* S. (Miridae) lays eggs singly, deep inside the soft tissues of tender shoots, inflorescence branches etc. The presence of small thread-like chorionic processes projecting outside is indicative of the presence of eggs inside the tissues. Eggs are almost reniform in shape and creamy white in colour. At a temperature range of 24–32°C and a daily average relative humidity of 47–100%, the incubation period lasts for 6–7 days and the nymphal period with five instars is completed in ten days. The build-up of the population starts in October synchronising with the new flushes and the population reaches its maximum during mid-January when the cashew trees are in full blossom.

The biology of the defoliator *Metanastria hyrtaca* C. (Lasiocampidae) was studied under a temperature range of 26–35°C and a daily average relative humidity of 41–100%. Incubation period lasted for nine days, the caterpillar phase comprising six instars took 35–40 days and the pupal stage 12 days. The caterpillars are gregarious in habit. The moth lived for six days during which period it layed up to 299 eggs.

The cashew stem borer *Plocaederus ferrugineus* (Cerambycidae) lays eggs inside fresh tissues and in the crevices of the bark. Egg is ovoid in shape, dirty white in colour, and measures 4.5 x 2.0 mm. Under a temperature range of 26–35°C and 47–100% relative humidity, the incubation period lasts from 4–6 days. The grub phase lasts for 6–7 months.

Infestation by tea mosquito, flower thrips, and fruit borers was found to account for 12.3% fruit drop during mustard stage, 16.4% during pea nut stage, and 1.1% during later stages.

Ent. III (176) and Experiment 39. **Chemical control of pests**

(G. B. Pillai and V. A. Abraham)

Laboratory screening tests with different concentrations of endosulfan and trichlorphon were carried out against cashew stem borer grubs.

A field trial for the curative control of stem borer using carbaryl, pyrethrins piperonyl butoxide, dimethoate, trichlorphon (as injection and

drenching the base), phorate granules, and aluminium phosphide tablets (applied into tunnels in the stem) is in progress. For this, 56 trees with different degrees of infestation have been treated with the above insecticides, and they are under observation. Another field trial has been laid out at the Kerala Govt. Cashew Plantations, Periye, to assess the comparative efficacy of different insecticides including endosulfan (which has been found efficacious in reducing inflorescence blight) when applied as low volume sprays. This experiment involves testing four insecticides, *viz.*, endosulfan, fenitrothion, malathion + fenitrothion, and phosphamidon, at two levels 0.1 and 0.2%. Three sprayings are given corresponding to the emergence of flushes, panicles, and fruit set.

The study is in progress.

GENETICS

SUMMARY

A systematic survey of wild and cultivated pepper has been initiated. So far, 136 collections have been made and this include 38 wild collections. In a comparative yield trial with 31 ginger types, *Wynad Kunnamangalam*, *Poona*, *Wynad Local*, *Turan*, and *China* were high yielding. In a similar trial in turmeric with 38 types, *Ca 69 Dindigam*, *CLL 326 Mundukur*, and *Wynad Local* were the best.

Work in progress

Gen. I (813) and Experiment 13. **Collection, maintenance, and evaluation of pepper germplasm**

(P.K. Thankamma Pillai, N.M. Nayar, K.N. Murthy, and P. M. Kumaran)

A systematic survey of Western Ghats was taken up for collection of wild pepper. To begin with, collections were made from parts of Idikki (Devikulam and Peermedu), Kottayam (Periar, Konni, and Ranni), and Palghat (Silent Valley) districts of Kerala. So far, 136 indigenous and exotic accessions of pepper have been assembled.

Rooted pepper cuttings of seven cultivated varieties, *Uthirankotta*, *Kalluvally*, *Arikotanadan*, *Nilgiri*, *Panniyur-I*, *Sullia*, and *Narayakodi* were sent to the Nematologist, Kayangulam, to study their reaction to the root-knot nematode.

Seedlings of *Poonjaranmunda* raised during the last season are being planted in the main field for studying their performance.

Gen. I (813) and Experiment 14. **Intervarietal hybridisation in pepper**

(M. C. Nambiar)

Crosses were made among eight varieties possessing economically desirable characters. Seedlings raised from open pollinated seeds of several varieties had been planted at Panniyur in 1972. Three seedlings of *Kottanadan* and *Sullia* flowered during the year *i. e.*, in the first year of their orchard life itself. One of the progenies of *Kottanadan* was vigorous in growth and produced 36 spikes. The spikes are long with closely set berries. Further evaluation is in progress.

Gen. II (813) and Experiment 18. **Germplasm collection and screening in ginger**

(P. K. Thankamma Pillai and Sr. Res. Asst., (Agronomy, Kasaragod)

Analysis of data on number of tillers, height of plants, and number of leaves collected from 31 types (three exotic and 28 indigenous) showed that they differed significantly for these characters. The types *Wynad Kunnamangalam*, *Poona*, *Wynad Local*, *Turan*, and *China* were high yielding, and *Peechi* and *Uttar Pradesh* were low yielding. Plant height and leaf number were found to be associated with rhizome yield.

Thirty five types including six exotic types were assembled during the year.

Gen. III (813) and Experiment 20.

Germplasm collection and catalogueing in turmeric

(P. K. Thankamma Pillai, Sr. Res. Asst., (Agronomy Kasaragod), and M. C. Nambiar)

Data collected from 38 types (including 18 clonal selections) showed that they differed significantly for all the characters studied except for tiller number. The type *Ca 69 Dindigam* gave the highest yield followed by *CLL 326 Mundukur* and *Wynad Local*. It was lowest in *Armoor, Kodur types,* and *T. Sunder*. The characters, height of shoots and size of leaves, were associated with yield. Based on the morphological characters of rhizomes and yield, further clonal selections have been made from the 37 types and their field performance will be studied in progeny row trials. Quality characters of the selections are also being determined.

AGRONOMY

SUMMARY

In a manurial *cum* seed rate trial in ginger a seed rate of 1800 kg/ha was found to be the best. A field experiment has been laid out in pepper to determine its agronomic requirements.

Work in progress

Agr. I (813) and Experiment 19. **Manurial *cum* seed rate trial in ginger** (Sr. Res. Asst., (Kasaragod) and P. K. Thankamma Pillai)

To study this, an experiment was laid out in a $3^2 \times 2$ split plot factorial design with two replications. Higher levels of N produced significant effect on the number of tillers, number of leaves, length of leaves, and breadth of leaves. A seed rate at 1800 kg/ha produced significantly superior effect on number of tillers, height of plants, length and breadth of leaves, and yield of rhizomes.

Agr. IV (813). **Determining agronomic requirements of pepper**

(1) Experiment 17. NPK requirements

(P. M. Kumaran and Sr. Res. Asst., (Vittal)

The field experiment has been laid out in a 3^3 factorial split plot design with 16 standards (eight dead and eight live) per plot and two replications. The variety used is Panniyur–1.

Fertilizers were applied at the recommended dose. The growth of the variety was uneven.

(2) Experiment 16. Efficacy of live and dead standards

(Sr. Res. Asst., (Vittal) and K. N. Murthy)

Both the live *(Erythrina indica)* and dead (teak wood) standards were planted in the field.

(3) Effect of shade on growth and yield

It is proposed to lay out an experiment to determine the shade tolerance of selected varieties of pepper by planting them in the open and in an arecanut garden containing variable numbers of trees per unit area.

SCh. II (176 and 813). **Quality studies on spices**

(C. K. Mathai and Biochemist (Vittal)

1. Determination of chemical constituents of ginger, pepper, and turmeric germplasm

Twenty ginger varieties were analysed for their dry matter and oleoresin contents. Dry matter varied from 11·1% in *Rio de Janeiro* to 28.4% in *Ernad Chernad*. Acetone-extracted oleoresin was the highest in *Jorhat* (10.1%). The full data are given in Table 60.

Table 60. Dry matter and oleoresin contents of ginger varieties

Sl. No.	Name of variety	Oleoresin (%)		Dry matter (%)
		Acetone extracted	Alcohol extracted	
1	Maran	5.0	10.7	16.1
2	Rio de Janeiro	6.6	8.1	11.1
3	Thingpuri	4.8	5.4	21.3
4	Nadia	5.6	7.4	17.0
5	Himachal Pradesh	5.2	6.5	22.0
6	Sierra Leone	6.8	8.7	21.4
7	Narasapattom	9.0	10.3	17.4
8	Burdwan	5.7	7.9	12.7
9	Poona	8.6	7.2	27.5
10	Karakkal	7.6	11.6	20.4
11	Vengara	6.8	7.5	13.5
12	Ernad Manjeri	5.6	7.4	25.5
13	Jorhat	10.1	10.2	20.0
14	Turan	6.4	8.8	16.3
15	Thodupuzha	6.7	6.9	19.3
16	Bajpai	8.8	9.2	17.9
17	Ernad Chernad	7.3	9.1	28.4
18	Tinladium	8.6	9.0	24.1
19	Valluvanad	6.6	10.8	19.7
20	Mananthody	9.3	13.0	12.4

2. Seasonal variation in chemical constituents of spices

The rate of accumulation of oleoresin, crude fibre, and dry matter was studied in seven ginger varieties at monthly intervals beginning from third month onwards (Tables 61 and 62). Yield of oleoresin was higher when alcohol was used as the solvent. Dry matter increased with maturity and crude fibre content decreased with age.

Table 61. EFFECT OF TIME OF HARVESTING (MATURITY) ON OLEORESIN CONTENT IN GINGER

Varieties	Acetone-extracted (%)					Alcohol-extracted (%)				
	3rd month	4th month	5th month	6th month	7th month	3rd month	4th month	5th month	6th month	7th month
Maran	12.5	11.5	9.0	5.3	5.0	22.6	18.2	12.5	13.2	10.7
Rio de Janeiro	11.2	13.6	11.9	11.0	6.6	22.3	19.4	16.7	14.7	8.1
Thingpuri	11.9	10.0	7.2	6.5	4.8	21.6	17.6	10.6	9.3	5.4
Nadia	11.4	6.6	5.6	4.2	5.6	23.2	10.1	8.3	6.4	7.4
Himachal Pradesh	16.1	13.1	5.7	5.4	5.2	26.5	19.7	10.8	7.6	6.5
Sierra Leone	13.5	14.2	7.9	5.6	6.8	22.1	23.7	15.5	11.3	8.7
Narasapattom	11.9	9.7	5.5	5.6	9.0	19.7	16.0	9.7	7.4	10.3
Burdwan	10.1	11.8	7.5	4.4	5.7	18.6	17.8	12.9	6.9	7.9

Table 62. EFFECT OF TIME OF HARVESTING (MATURITY) ON CRUDE FIBRE AND DRY MATTER CONTENT IN GINGER

Varieties	Dry matter					Crude fibre				
	Period of harvest					Period of harvest				
	3rd month	4th month	5th month	6th month	7th month	3rd month	4th month	5th month	6th month	7th month
Maran	5.5	7.8	5.9	7.1	16.1	15.6	14.2	10.3	12.7	9.0
Rio de Janeiro	5.6	6.4	5.4	11.6	11.1	15.4	14.4	13.2	11.5	12.5
Thingpuri	5.5	9.8	6.5	18 7	21.3	17.0	9.4	6.7	6.8	7.8
Nadia	6.4	8.5	16.4	17.5	17.0	16.0	6.6	4.1	4.5	6.0
Himachal Pradesh	6.4	7.1	16.9	11 5	22.0	. .	15.0	6.5	7.2	1 6
Sierra Leone	7.7	6.9	12.7	11.1	21.4	. .	16.5	7.9	6.1	4.8
Narasapattom	5.5	7.0	9.0	9.2	17.4	. .	11.0	6.3	6.0	3.7
Burdwan	5.8	5.6	7.5	11.8	12.7	. .	13.4	7.3	5.0	1.8

PLANT PATHOLOGY

SUMMARY

In the field trial laid out at Santhampara (High Ranges, Kerala) using ten fungicides for the control of 'azhukal' disease of cardamom, Bordeaux mixture 1% was the most effective. *Phytophthora* sp. was isolated from quick wilt affected pepper vines, and *Fusarium* sp., and frequently, *Diplodia* sp. and *Rhizoctonia* sp., were isolated from slow wilt infected pepper vines. For rhizome rot of ginger and turmeric, treatment with Ceresan wet 0.1%, reduced the rot by nearly 50% and almost doubled the yield over the control.

Work in progress

Path. IV (813) and Experiment 32. **'Azhukal' disease of cardamom** (K. K. N. Nambiar and Y. R. Sarma)

Based on last year's data obtained from field trials and laboratory screening of different fungicides against the pathogen, a fresh field trial was laid out at Santhampara (High Ranges, Kerala) using ten different fungicides comprising Bordeaux mixture, copper oxychlorides, dithiocarbamates, and systemic fungicides. A wetting agent was used along with the fungicides except Bordeaux mixture. The trial was laid out in a randomised block design with 11 treatments, three replications, and ten plants per treatment. Two sprayings were given in June and August. The data on incidence of disease confirmed last year's results that Bordeaux mixture 1% was most effective in reducing the disease incidence (2.0%) against 28.2% in the untreated control. Copper oxychlorides were on par with Bordeaux mixture in reducing the disease incidence.

Five large scale demonstration *cum* trial plots have been maintained in Santhampara and Udumbanchola (Kerala) using Bordeaux mixture 1% @ 1 and 2 *l* / clump. The results showed that Bordeaux mixture at 1 *l* / clump was as equally effective as 2 *l* dosage in reducing the incidence.

Path. II (813) and Experiment 35. **Slow wilt and quick wilt diseases of pepper** (K. K. N. Nambiar and Y. R. Sarma)

Phytophthora sp. isolated from quick wilt-affected vines was found to be pathogenic to betel vine *(Piper betel L.)* and a wild species of *Piper.*

In the case of slow wilt disease, extensive necrosis was noticed in the functional lateral roots. *Fusarium* sp. was constantly isolated from roots of affected vines. In addition, *Diplodia* sp. and *Rhizoctonia* sp. were also isolated frequently.

Since the nematode *Radopholus similis* also has been observed to be associated with the slow wilt disease, observational trials using nematicides have also been laid out.

Based on the *in vitro* screening of fungicides against the fungi isolated from quick and slow wilt affected pepper vines, separate field control trials have been laid out using Bordeaux mixture, and copper oxychlorides. They have nine treatments, and three replications with ten vines per treatment.

Path. III (813) and Experiment 36. **Rhizome rot of ginger and turmeric** (Y. R. Sarma and K. K. N. Nambiar)

In addition to *Pythium* sp., a bacterium has also been isolated from soft rot affected ginger rhizomes. The actual role played by this bacterium in the incidence of disease is yet to be determined.

In vitro screening of fungicides showed that Ceresan wet 0.1%, Thiride, and Ziride (both at 0.3%) were fungicidal. The field control trials conducted during the previous season showed that the incidence of soft rot was reduced to 45.8% in Ceresan wet-treated plots as against 71.4% in control. The fungicide treatment produced a mean yield of 4.0 kg rhizomes/bed (3 m^2) as against 2.2 kg / bed in the untreated control. A fresh field trial using 14 fungicides has since been laid out.

Field inoculation tests conducted on 29 types of ginger showed that none of them was resistant to the disease.

Path. V (813) and Experiment 40.

Leaf spot disease of ginger

(Y. R. Sarma and K. K. N. Nambiar)

Based on the *in vitro* screening of fungicides against the causal organism *Phyllosticta zingiberi*, a field trial for the control of the disease was laid out using 16 fungicides. The incidence of disease was less in the field during the period under report as compared to the previous year, and hence no conclusions could be drawn.

ENTOMOLOGY

SUMMARY

Biology of the ginger and turmeric leaf roller *Udaspes folus*, seasonal abundance of the pepper 'pollu' beetle *Longitarsus nigripennis* and the cardamom thrips *Taeniothrips cardamomi* were studied. The caterpillars of *U. folus* was found to be infected by two entomogenous bacteria and two hymenopterous parasites. In a field trial against the turmeric shoot borer, mephospholan 5% granules @ 1.5 kg active ingredient per ha was the most effective.

Work in progress

Ent. II (813) and Experiment 38. **Biology and bionomics of insect pests** (V. A. Abraham and G. B. Pillai)

1. Ginger and Turmeric

Biology of the leaf roller *Udaspes folus* C. was studied. Under a temperature range of 27–33°C and 71–100% relative humidity, the incubation period lasted for four days, the caterpillar phase comprising five instars, 15.3 days in turmeric and 18.2 days in ginger, the prepupal period one day, and the pupal period 6.2 days. The average duration from egg to adult worked out to 26.5 days in turmeric and 29.4 days in ginger. The longevity and fecundity of adults are being studied.

Diseased caterpillars of *U. folus* collected from the field yielded two bacterial isolates. These have been identified as *Enterobactor cloacae* and *Pseudomonas* sp. In further tests, the former has proved to be a potential pathogen. The actual role played by the bacterium in producing septicaemia in caterpillars is under study. Two species of parasites were also obtained from *U. folus*. They are *Apanteles* sp. from prepupal caterpillar and a chalcid from pupae.

Observations on incidence of shoot borer, *Dichocrocis punctiferalis* Guen. on different varieties/types of turmeric showed that all the varieties were equally susceptible to the pest.

2. Pepper

Studies on the seasonal abundance of 'pollu' beetle *Longitarsus nigripennis* Mots. showed that the pest was present in the field during August–January with a peak in October–November. The intensity of incidence of the top shoot borer *Laspeyresia hemidoxa* Meyr. on three age groups of Panniyur–1 showed 6.4–26.1% shoot attack in 1972 and 1.7–5.4% in 1973.

3. Cardamom

The cardamom thrips *Taeniothrips cardamomi* was observed to be present almost throughout the year with a peak in February and a very low population during the SW monsoon period. The reaction of different varieties of cardamom and allied genera to this thrips is being studied.

Ent. III (813) and Experiment 39. **Chemical control of pests** (G. B. Pillai and V. A. Abraham)

1. Ginger and Turmeric

A field trial on the control of ginger and turmeric shoot borer using nine granular insecticides, lindane, carbaryl, carbaryl + lindane, carbofuran,

trichlorphon, mephospholan, phorate, thiodemeton, and disulfoton has been laid out during the current season. The incidence of shoot borer in ginger was negligible, and as such, it was not included for analysis. In the case of turmeric the data showed that mephospholan 5% granules @ 9 g/3 m² (1.5 kg active ingredient/ha) reduced shoot borer incidence significantly. The mean percentage incidence in mephospholan-treated beds was 8.4 as against 15.3 in control.

2. Pepper

Based on the indications obtained from the previous year's trials, two series of trials using quinalphos, malathion + fenitrothion, dimethoate, phosphamidon, and endosulfan (all 0.1%), and DDT 0.2% as foliar spray, and granular insecticides like phorate 10 g, thiodemeton 20 g, carbaryl 15 g, carbaryl + lindane 15 g, carbofuran 15 g, mephospholan 10 g, and trichlorphon 10 g applied to the basal soil of vines twice in August and October, have been in progress during the current season The data on incidence of 'pollu' beetle on spikes and berries are given in Table 63. The study is in progress.

Table 63. Effect of insecticides on the incidence of 'pollu' beetle

	Treatment	% attacked spikes (Mean value)*	% attacked berries (Mean value)*
1	Quinalphos 0.1%	18.9 (24.7)*	2.0 (7.2)*
2	Malathion + fenitrothion 0.1%	24.5 (28.8)	2.4 (8.1)
3	Dimethoate 0.1%	12.6 (19.2)	0.9 (4.5)
4	Phosphamidon 0.1%	29.5 (31.7)	3.4 (19.1)
5	Endosulfan 0.1%	16.8 (22.9)	2.3 (8.0)
6	DDT 0.2%	35.8 (36.1)	5.6 (13.6)
7	Control	68.5 (57.2)	17.6 (24.0)

* Transformed values in parenthesis

S.E/plot	6.8*	3.3
C.D	12.0	5.8

Table 64. PROGRAMME OF WORK (ALL INDIA CO-ORDINATED SPICES AND CASHEWNUT IMPROVEMENT PROJECT) FOR 1974

Project No.	Name of the Project	Venue
(a) CASHEW		
Gen. I (176) and Experiments 1 & 3	Collection, maintenance, and evaluation of germplasm	Vittal, Anakkayam, Bapatla, Vridhachalam, Coimbatore, Timkur, and Mohitnagar
Gen. II (176)	Varietal improvement of cashew	Vittal, Vridhachalam, Bapatla, and Vengurla
Experiment 22	Floral biology	
Experiment 2	Standardisation of seedlings selection methods	
Experiment 4	Hybridisation and selection	
Gen. III (176) and Experiment 5	Propagation studies	Vittal, Bapatla, Vridhachalam, Vengurla, and Vatapalam
Agr. I (176) and Experiments 6 & 7	Nutritional requirements	Kasaragod and Vridhachalam
Agr. VI (176) and Experiment 8	Pruning trials	Vittal and Vridhachalam
Path. I (176) and Experiment 34	Inflorescence blight	Vittal and Kasaragod
Ent. I (176) and Experiment 37	Studies on the biology and bionomics of insect pests	Kasaragod
Ent. III (176) and Experiment 39	Chemical control of pests	Kasaragod
(b) SPICES		
Gen. I (813) and Experiment 13	Collection, maintenance, and evaluation of pepper germplasm	Kasaragod, Vittal, and Panniyur

Gen. II (813) and Experiment 18	Germplasm collection and screening in ginger	Kasaragod and Vittal
Gen. III (813) and Experiment 20	Germplasm collection and cataloguing turmeric	Kasaragod
Agr. I (813) and Experiment 19	Manurial cum seed rate trial in ginger	Kasaragod
Agr. IV (813) and Experiment 20	Determining the agronomic requirements of pepper	
Experiment 16	NPK requirements	Vittaland Panniyur
Experiment 17	Efficacy of live and dead standards	Vittal
	Effect of shade on growth and yield	Vittal
SCh. II (176 and 813) and Experiment 23	Quality studies on spices	Vittal and CFTRI, Mysore
Path. IV (813) and Experiment 32	'Azhukal' disease of cardamom	Kasaragod and Santhampara
Path. II (813) and Experiment 35	Slow wilt and quick wilt of pepper	Kasaragod, Alakode, and Bandadka
Path. III (813) and Experiment 36	Rhizome rot of ginger and turmeric	Kasaragod
Path. V (813) and Experiment 40	Leaf spot disease of ginger	Kasaragod
Ent. II (813) and Experiment 38	Biology and bionomics of pests	Kasaragod, Taliparamba, Panniyur, and Pampadumpara
Ent. III (813) and Experiment 39	Chemical control of pests	Kasaragod, Taliparamba, Panniyur, and Pampadumpara

ABSTRACT OF REPORT OF THE CO-ORDINATING CENTRES OF THE ALL INDIA CO-ORDINATED SPICES AND CASHEWNUT IMPROVEMENT PROJECT

Besides the CPCRI, and its regional station at Vittal, the All India *Co-ordinated Spices and Cashewnut Improvement Project was operating at the* following centres also.

Indian Institute of Horticultural Research, Hasserghatta

Centre : Gonicoppal

Kerala Agricultural University, Mannuthy

Cashew Research Station, Anakkayam

Cardamom Research Station, Pampadumpara

Pepper Research Station, Panniyur

Tamil Nadu Agricultural University

Cashew Research Station, Vridhachalam

University of Agricultural Sciences, Bangalore

Regional Research Station (UAS), Mudigere

Andhra Pradesh Agricultural University

Cashew Research Station, Bapatla

Konkan Krishi Vidhya Peeth

Cashew Research Station, Vengurla

Himachal Pradesh University, Agricultural Complex

Fruit Research Station, Kandaghat

An abstract of the work carried out at these centres is presented below.

CASHEW. The germplasm collection comprises of 88 types in Anakkayam, 297 in Bapatla, 177 in Vridhachalam, and 78 in Vengurla. At Anakkayam, highest yields were given by the seedling type Bla 139–1 followed by the clonal type Ul 28–1. At Bapatla, 11 types yielded more than 10 kg nuts per tree, 64 between 5 and 10 kg, and 222 below 5 kg. At Vridhachalam, 51 trees were identified as good yielders.

In vegetative propagation studies, budding was not found to be successful at Anakkayam. Layers prepared in the month of May and separated in August established well under Bapatla conditions. Patch budding done in August gave 79% success at Vridhachalam. Both budding and veneer grafting

were successful under Vengurla conditions, the best season being July-August for veneer grafting and September-October for budding.

CARDAMOM. In the preliminary yield trial involving seedling progenies of 15 of the 25 high yielding clumps available at Mudigere, they yielded 171 – 388.64 g green capsule/plant. Eight types with different qualitative and quantitative characters have been collected and planted at Pampadumpara. Intrageneric crosses were made between *Elettaria*, *Amomum*, *Hedychium*, and *Alpinia* and the seeds obtained have been sown in nursery.

At Gonicoppal, Difolatan at 0.3% was found to be the best fungicide in the control of nursery leaf spot. The cultivars APG 1, 2, 3, 4, and 5 contracted 'katte' disease when inoculated with viruliferous *Pentalonia nigronervosa*. Vector studies revealed that *Toxoptera citricida* and *Aphis maidis* were able to transmit 'katte' under laboratory conditions, but were not so efficient as *P. nigronervosa*. At Mudigere, *Alpinia* sp. exhibited 'katte' symptoms when inoculated with viruliferous aphids.

PEPPER. At Panniyur, 42 types of pepper including two Indonesian varieties are available in the germplasm. Intervarietal hybridisation was carried out in 15 combinations using eight varieties.

SUMMARY OF THE REPORT

COCONUT

Two cultivars from Papua and New Guinea, Karkar and Markham, and two from Surinam, Surinam Tall and Surinam Dwarf, were added to the collection. The cultivars Java, New Guinea, and San Ramon yielded 22–26 kg copra per tree per year whereas it was only 13 kg in the local West Coast Tall. Colour of petiole was found to be a helpful character for the identification of Dwarf x Tall hybrids. The variety Chowghat Dwarf Orange showed a high selfing intensity (47%) as compared to the Tall cultivars. Interspadix overlapping of flowering played a major role in the selfing of Talls, whereas it was intraspadix overlapping in Dwarf Orange.

In agronomic trials, D x T hybrids were found to bear earlier and produce a higher rate of leaf production than T x D hybrids and Talls. During the prebearing period, nitrogen improved the rate of leaf production and phosphorus increased the number of functional leaves. An experiment was initiated to determine the fertilizer requirement of adult palms grown under neglect. Bimonthly split application of manure to young palms produced a higher rate of leaf production and more vigour as compared to application at wider intervals. A series of trials with tuber crops, pulses, and oil crops as inter - and mixed crops were continued as part of the effort to improve the productivity of coconut plantations. In general, the tuber crops performed the best. When cacao was planted as a mixed crop with coconut, it not only produced a reasonable yield of cacao, but also increased the yield of coconut by 40–50%. When nursery beds were fertilized, it resulted in more vigourous seedlings with higher nitrogen and chlorophyll content in the leaves. In the agrostology plot at Kayangulam, where fodder grass is mix-cropped with coconuts and milch cows are maintained, the overall yield of palms increased by 23%. In an experiment to evaluate the comparative efficacy of different sources of phosphatic fertilizers in laterite soil, available phosphorus status of the soil was found to be the highest with the addition of superphosphate. In a sandy soil, the seedlings receiving cattle manure showed better growth as compared to those receiving other organic manures. Foliar yellowing and rubbery kernel in coconut were generally associated with low levels of Mg and S in soil and imbalance of nutrient cations in the leaves.

In the physiological studies, a high carbohydrate reserve in the stem and a high C–N ratio were found to be necessary for the commencement of flowering. Rate of apparent photosynthesis in adult WCT palms was significantly correlated with total chlorophyll content, annual yield of nuts, and the number of leaves on the crown. The presence of an additional amino acid was detected in T x D hybrids. It has been tentatively identified as pipecolic acid.

Villages bordering Kerala, in the districts of Ramnad, Madurai, and Coimbatore in Tamil Nadu, were found to be free of the root (wilt) disease. The roots of T x D and D x T palms also produced internal disorganisation before they showed visual symptoms of the disease. Four year old WCT seedlings, grown in concrete tubs containing Peechi soil (healthy area) mixed with roots of diseased trees, developed flaccidity of the leaflets comparable to that of the root (wilt) disease. Artificial pollination of diseased and healthy palms with pollen from diseased trees was carried out to study the extent of seed transmission of the disease. In the experiment laid out to study the role of nutrients on the incidence of disease, seedlings under treatment receiving no Mg developed foliar yellowing. The levels of polyphenol oxidase and peroxidase were significantly higher in the roots of root (wilt) diseased palms. A factor suspected to be phenolic was constantly present in the leaves of palms in the healthy area, while it was absent in the leaves of palms of the diseased area.

High populations of the burrowing nematode *Radopholus similis* (upto 562 adults per one gram soil) were recorded from the roots of palms affected by the disease. None of the samples from healthy areas, excepting the roots of WCT seedlings from the Institute nursery, yielded this nematode.

From the root and bark of palms affected with stem bleeding, a fungus, yet to be identified, and having white mycelium and clamp connections was isolated. The fungus was found in some healthy samples also. In the studies on bud rot disease, spores of *Phytophthora palmivora* were found to survive for 11–17 months in infected plant tissues and in agar culture mixed with steamed soil. Inoculation of bacteria on *P. palmivora* infected tissues hastened further rotting and secondary infection.

Mechanical, chemical, biological, and integrated methods of control trials were continued against the pests of coconut. In laboratory tests, arprocarb was found to be the most efficient insecticide against the grubs of the rhinoceros beetle, *Oryctes rhinoceros* L., with the least deleterious effect on the beneficial predators *Santalus parallelus* and *Agrypnus* sp. The exotic predator, *Platymeris laevicollis* G., was effective in reducing the pest infestation. The nematode DD–136 was parasitic on the larval stages of the beetle. In the integrated control trials against the leaf eating caterpillar *Nephantis serinopa*, the insecticides BHC 0.2% and malathion 0.05% adversely affected the parasites. Garlic oil suspension in water, when applied to the petioles of the palms, effectively controlled the grubs of the red palm weevil *Rhynchophorus ferrugineus* F. Injection of trichlorphon 0.2% was effective in 92% of the red palm weevil infested palms. Radiation induced sterile males were liberated for the control of the red palm weevil. The viability of the eggs of the weevils in the experimental area was found to be 70% as against 95.7% in the natural population. The reduction in viability could apparently be attributed to the released sterile males.

Some Eriophyid mites (which are known to be vectors of plant viruses) were recorded from coconut foliage. Feeding a mixture of chemosterilants (a mixture of 1.5 mg colchicine and 37.5 mg furadantin) to female rats effectively prevented conception in them.

Nearly 36,000 seedlings were distributed to the cultivators and government agencies. Five new demonstration plots were set up in different soil types bringing the total number of demonstration plots to 14. In addition, 12 fertilizer trials were laid out in cultivators' fields to determine the most economic fertilizer levels under field conditions.

ARECANUT

The already released variety Mangala and the exotic introductions, VTL-11, VTL-12, VTL-13, and VTL-17, continued to yield better than the others. Of the nine Indian cultivars, the types Sweet Areca and Thirthahalli were the best. By using colchicine, tetraploids were produced for the first time in arecanut. These were obtained in the types Mangala and VTL-11. Crosses were made in 93 combinations between different varieties, species, and genera to evolve types possessing desirable characters. The differences in yield due to selection of seed nuts were not significant.

The optimum spacing for planting varied from one region to another. At Peechi (Kerala), it was found to be 2.7 m x 2.7 m, at Hirehalli (Karnataka) 1.8 m x 3.6 m, and at Kahikuchi (Assam), 1.8 m x 2.7 m. Planting at a depth of 90 cm and irrigating once in five days gave the highest yield at Vittal. The response to nitrogen was significant at Vittal, Kahikuchi, and Peechi. Among the six cacao hybrids tried as a mixed crop with arecanut at Peechi, the hybrid I 195 x ICS 60 gave the highest yield.

The cost of cultivation differed from place to place. At Vittal, it was Rs. 5,970.44 per ha with a yield of 3,760 kg *chali*. The corresponding figures for Hirehalli were Rs. 4,350.00 and 1,920 kg, respectively, and for Palode, under rainfed conditions, they were Rs. 2,965.00 per ha and 2,200 kg per ha, respectively.

Phosphatic fertilizers at their highest doses (60-120 kg P_2O_5 per 500 palms) raised the available P-status of soil to the level of sufficiency (25 ppm). Thermophosphate and Suphala were better than superphosphate, Factamfos, and Ultrafos in releasing available phosphate in the laterite soil at Vittal. Among the various green manuring crops tested, the highest amounts of green matter were given by *Pueraria javanica* at Vittal and *Centrocema pubescens* at Hirehalli. A crop of *Pueraria* giving 14.35 tonnes green matter per ha supplied to the soil 99.33 kg N, 16.54 kg P_2O_5 and 59.06 kg K_2O.

Pilot plant trials showed that arecanut pulp could be used for producing wrapping paper when mixed with long-fibred pulp.

Investigations on the yellow leaf disease were continued. *Areca triandra* was not affected by the disease. Disease symptoms were not produced on any of the large number of test plants when they were inoculated with crude leaf sap of diseased palms. Indicator plants grown *in situ* and in pots containing infested soil did not show any disease symptoms. Bacterial streaming movement was noticed in 70% of the root samples collected from Palode.

The fungus *Ganoderma lucidum* was isolated from 57% roots of 'anabe' disease affected palms. The fungus responsible for the die-back of inflorescence was identified to be a *Colletotrichum* stage of the fungus *Glomerella cingulata*. *In vitro* trials with this fungus showed that Leytosol, Captan, and Thiram were fungicidal.

The life cycle of *Stethorus* sp., the predatory beetle of red mite, was completed in 13–15 days. An adult beetle consumed 2.4–6.5 red mites in an hour. The best insecticide for the control of white grub was Rogor 5% granules applied at 30 kg per ha.

CASHEW

The number of accessions in the germplasm collection was brought up to 199. Floral biology studies showed that the number of bisexual flowers in a panicle varied from 0 to 74 and male flowers from 106 to 1,380. Male flowering in a panicle was completed in 52–122 days and bisexual flowering in 1–105 days.

From an NPK fertilizer experiment laid out separately on air layers and seedlings, the main effect of N was significant for both number and weight of nuts. Application of 300 g N/tree gave the maximum response.

Inflorescence blight of cashew was found to be caused by the attack of tea mosquito *Helopeltis antonii*. The fungi found associated with the blighted flower bunches were shown to be only secondary saprophytic colonizers. Endosulfan 0.05%, when applied as a high volume spray twice, at the emergence of panicles and at fruit set, controlled the pest. In the treated plots, the yield of nuts per tree was 2.03 kg as against 1.21 kg in the untreated trees.

As much as 30% of immature fruits was estimated to be lost due to attack by tea mosquito, flower thrips, and fruit borers. The tea mosquito population was found to reach its peak in mid-January when the cashew trees are in full blossom.

PEPPER

One hundred and thirty six accessions including 38 wild varieties were available in the germplasm. Field experiments have been laid out to determine NPK requirements, efficacy of dead and live standards, and effect of shade on growth and yield.

The fungus *Phytophthora* sp. isolated from quick wilt disease affected vines was pathogenic to betel vine. In addition to *Fusarium* sp., *Diplodia* sp. and *Rhizoctonia* sp. were also isolated from the slow wilt disease affected vines. Since the nematode *Radopholus similis* was also observed to be associated with the slow wilt disease, field trials were laid out with nematicides to determine their effect on the incidence of this malady.

The incidence of 'pollu' beetle *Longitarsus nigripennis* Mots. was estimated to cause a loss of upto 40% of the berries. The infestation could be reduced by 70-81% with two sprayings of dimethoate 0.1% or quinalphos 0.1%. They were also more effective than a residual insecticide like DDT which reduced the incidence by only 46% over the control. Studies on the seasonal abundance of the 'pollu' beetle revealed that the population reached its peak in October-November.

CARDAMOM

Field trials laid out using different fungicides at Santhampara (High Ranges of Kerala) to study their effectiveness against 'azhukal' or panicle rot showed that two sprayings with Bordeaux mixture 1% or copper oxychloride 0.2% with a wetting agent, applied at 40 days interval in August and September effectively controlled the disease. The cardamom thrips were found to be present almost throughout the year, but they reached their maximum in February.

GINGER AND TURMERIC

The ginger types Wynad Kunnamangalam, Poona, Wynad Local, Turan, and China were high yielders. Height of the plant and number of leaves were found to be associated with yield of rhizomes. A seed rate of 1,800 kg/ha was found to be the best. In turmeric, the highest yield was obtained in the type Ca 69 Dindigam, followed by CLL 326 Mundukur and Wynad Local.

From the soft rot affected rhizomes of ginger a bacterium was also isolated in addition to *Pythium*. Ceresan Wet reduced the incidence of the disease (upto 45.8%) and increased the yield (4.0 kg/rhizomes/bed against 2.2 kg/bed in control). A trial was laid out with fungicides for the control of leaf spot of ginger.

The life cycle of the leaf roller was completed in 26.5 days in turmeric and 29.4 days in ginger. Diseased caterpillars of the pest in the field gave two bacterial isolates. Mephospholan 5% granules @ 1.5 kg active ingredient / ha was the most effective insecticide against shoot borer of turmeric.

PUBLICATIONS

1. Antony, J. (1973). Biological control of the pests of coconut and arecanut (Malayalam). *Vignana-kairali* **5** (2) : 119–123.

2. Bavappa, K. V. A. (1973). Utilisation of waste products of coconut. Invited paper read at the Symposium on Utilisation of Agricultural Wastes, Agricultural Sciences Session, *Golden Jubilee Session of the Indian Science Congress*, Chandigarh.

3. Bavappa, K. V. A. (1973). Research advances and development in plantation crops with special reference to export oriented items. Paper presented at the *National Symposium on Agricultural Development and Research since Independence*, New Delhi.

4. Bavappa, K. V. A. (1973). A hybrid seed garden for the west coast of India. *Coc. Bull.* **4** (1) : 6–7.

5. Bavappa, K. V. A. and Nampoothiri, K. U. K. (1973). Recent trends in coconut breeding. Paper presented at the *Second General Congress of SABRAO*, New Delhi (under publication).

6. Bhat, N. T. and Mohapatra, A. R. (1973). Scientific management practices for arecanut soils in India. *Arecanut and Spices Bull.* **5** (1) : 5–8.

7. George, E. (1973). Control of black beetle by microbes. *Coc. Bull.* **4** (4) : 2–3.

8. George, M. V. and Radha, K. (1973). Computation of disease index of root (wilt) disease of coconut. *Indian J. Agric. Sci.* **43** : 366–370.

9. Kamala Devi, C. B., Wahid P. A., and Pillai, N. G. (1973). A note on the extraction of potassium from coconut leaves. *Agric. Res. J. Kerala* **10** : 170–173.

10. Kurian, C. and Antony, J. (1973). Attempts at the biological control of the rhinoceros beetle. *Coc. Bull.* **3** (11) : 2–4.

11. Kurian, C. and Sathiamma, B. (1973). Pests of coconut palm (Malayalam). *Vignanakairali* **5** (2) : 105–114.

12. Mathen, K. (1973). The lace winged enemy of coconut. *Coc. Bull.* **4** (8) : 2–4.

13. Mathen, K., George, M. V., and Kurian, C. (1973). A technique to estimate the population of *Stephanitis typicus* Distant (Heteroptera: Tingidae), a pest of coconut palm in Kerala. *Indian J. Agric. Sci.* **43** : 106–109.

14. Mathew, C. and Ramadasan, A. (1973). Chlorophyll stability index in different varieties and hybrids of coconut. *Curr. Sci.* **42** : 584–585.

15. Mohapatra, A. R., Vijayakumar, K., and Bhat, N. T. (1973). A study on nutrient removal by the cashew tree. *Indian Cashew J.* **9** (2) : 19–20.

16. Mohapatra, A. R., Pillai, S. S., Bhat, N. T., and Murthy, K. N. (in press). Growth character and mineral nutrient composition of arecanut seedlings as related to their cation exchange capacity. *J. Plantation Crops* **1** (Supplement).

17. Muliyar, M. K. and Wahid, P. A. (1973). Note on the movement and availability of phosphorus in a laterite soil as influenced by heavy phosphorus application with special reference to coconut. *Indian J. Agric. Sci.* **43**: 527–528.

18. Nambiar, M. C. and Ravindran, P. S. (1973). Pattern of genetic variation in the reproductive characters of coconut (*Cocos nucifera* L.). Paper presented at the *Second General Congress of SABRAO*, New Delhi (in press).

19. Nambiar, K. K. N. and Radhakrishnan Nair, R. (1973). Charcoal pod rot of cacao. *Indian Phytopath.* **25** : 595–597.

20. Nambiar, K. K. N., Sarma, Y. R., and Pillai, G. B. (1973). Inflorescence blight of cashew (*Anacardium occidentale* L.) *J. Plantation Crops* **1** : 44–46.

21. Pillai, G. B., Abraham, V. A., and Radhakrishnan, C. P. (1973). Insect pests of cashew and spices (Malayalam). *Vignanakairali* **5** (2) : 133–139.

22. Pillai, N. G. and Kamala Devi, C. B. (1973). Trace elements in plantation crops (Malayalam). *Vignanakairali* **5** (2) : 140-143.

23. Radha, K. (1973). Diseases of coconut palm (Malayalam). *Vignanakairali* **5** (2) : 119-123.

24. Radha, K. and Sethumadhava Menon, K. (1973). Leaf rot (Malayalam). *Kerala Karshakan* **21** (1) : 26-27.

25. Ramanandan, P. L. (1973). Use of common salt in coconut gardens. *Coc. Bull.* **4** (6) : 2-3.

26. Sahasranaman, K. N. and Sethumadhava Menon, K. (1973). Mixed farming in plantation crops (Malayalam). *Vignanakairali* **5** (2) : 123-126.

27. Sathiamma, B., George, M. V., and Kurian, C. (in press) Preliminary observations on seasonal variations in the larval population of coconut leaf eating caterpillar *Nephantis serinopa* M. in the field as correlated with meteorological factors. *J. Plantation Crops* **1** (Supplement).

28. Wahid, P. A., Kamala Devi, C. B., and Pillai, N. G. (1973). Inter-relationships among root CEC, yield and mono-and divalent cations in coconut (*Cocos nucifera* L.). *Plant and Soil* 40 : 607-617.

29. Wahid, P. A., Pillai, N. G., and Kamala Devi, C. B. (1973). Elimination of acid drift during potentiometric measurement of root CEC. *Curr. Sci.* **42** : 387-388.

30. Yadava, R. B. R., Bavappa, K. V. A., and Murthy, K. N. (1973). Diurnal rhythm and dry matter accumulation and carbohydrate contents in the leaves of arecanut palm (*Areca catechu* L.) *Proc. Nat. Acad. Sci. India* **42** (B): 403-405.

EXTENSION

1. Results of immediate practical application

Inflorescence blight of cashew is a serious malady resulting in a loss of about 30% flower bunches. It was previously considered to be caused by the infestation of tea mosquito *Helopeltis antonii* and a fungus *Gloeosporium mangiferae*. A combination spray with insecticide and fungicide was the recommended control measure for this malady.

Trials conducted at the Institute have revealed that infestation by tea mosquito alone is responsible for the incidence of the blight and the fungi found associated with the affected inflorescence are only secondary saprophytic colonizers. Endosulfan at 0.05%, when applied as high volume spray twice, first at flower emergence (November–December) and second at fruit setting (December–January), controls the blight. This recommendation eliminates the fungicide from the spray solution. Spraying the inflorescences with endosulfan helps in further reducing immature fruit drop caused by other insect attack.

2. Results likely to be useful but require further trials

i. Toddy is a popular alcoholic beverage collected mostly from the coconut palm. In Kerala State alone, nearly 50,000 persons are engaged in tapping and marketing it. About 40 million litres of toddy are sold annually in nearly 2,900 shops. It fetches an annual income of over Rs. 3.35 million to the State. The toddy now sold in the market is prepared under natural conditions of fermentation as it has a poor keeping quality. Consequently there is considerable wastage of toddy especially during seasons of overproduction. Pilot plant trials conducted in collaboration with CFTRI, Mysore, have shown that the unpleasant odour of toddy can be removed by a simple process and that the deodorised toddy after bottling and simple pasteurisation can be kept for at least six months without spoilage or loss of taste.

ii. Mixed cropping trials have been in progress from 1970 in a coconut plantation with cacao planted in single and double hedges. Both coconut and cacao were fertilized and sprinkler-irrigated at weekly intervals during dry months. Besides giving a normal crop of cacao, this practice has resulted in 40–50% increase in the yield of coconut. The double hedge system of planting of cacao was preferable to single hedge planting.

iii. The 'pollu' or flea beetle *Longitarsus nigripennis* Mots. is the most serious pest of pepper *Piper nigrum* in most of the pepper growing areas. The grubs of the beetle bore into immature berries, feed on the inner pulp, and make them completely hollow. Upto 40% berries are infested in certain endemic areas. The recommended control measure until now has been spraying with 0.2% DDT twice in July and October. Studies at the Institute have

shown that two sprayings (July and October) with dimethoate 0.1% or quinalphos 0.1% reduced the incidence to 81% and 70%, respectively, over the untreated control. They also provided the additional advantage that they replaced a residual insecticide like DDT.

3. Training

Eleven research workers and development officers and 24 instructional staff of Farmers' Training Centres from the various states of the country, where plantation crops are grown, were imparted training on the latest techniques of plantation crops breeding, cultivation, and protection.

4. Demonstration plots

Fourteen demonstration plots have been set up in different agroclimatic zones in the west coast of the country to find out the performance of various coconut hybrids and varieties. In the root (wilt) disease affected area, 82 demonstration plots have been set up to study the varietal reaction to the malady.

5. Seed production

At the Kidu Farm, (Nettana Post, South Kanara district, Karnataka), seedlings of various Tall and Dwarf varieties have been planted to produce genetically superior hybrid types. About 32,400 seedlings were distributed to farmers and government agencies. A total of 24,386 seednuts were sown in the nursery.

6. Operational research project

In order to adapt the new agricultural technology to the field conditions and to assess its economics, the Institute proposes to launch a comprehensive agricultural development programme in the Muttathody Village of Kasaragod NES Block. The bench mark survey was completed during the year.

7. Trials in cultivators' garden

To find out the most economic level of fertilizer dosage under cultivators' conditions, 12 field trials have been laid out in the Kasaragod area.

8. Publicity activities

The Institute continued to take part in a number of exhibitions. Farmers' Day was organized at Kasaragod from October 30-November 2.

The Institute staff also continued to answer large numbers of queries received from the public, both in person and by mail. They also continued to

examine diseased and infested plant specimens and tender suitable advice for remedying the problems. Whenever possible, visits of specialist staff to farmers' plots were also arranged.

8. Printing of pamphlets and brochures

The following pamphlets were revised and reprinted:

i. Package of practices for coconut (Malayalam and English)

ii. Package of practices for arecanut (Malayalam and English)

iii. Progress of work in root (wilt) disease (English)

CONFERENCES AND SYMPOSIA

During the year, the Staff Research Council met three times. The eighth meeting, which reviewed the projects in pathology, entomology, nematology, and microbiology, was held at the Regional Station, Kayangulam during 27-29 March. Dr. M. R. G. K. Nair, Director of Research, Kerala Agricultural University, guided the deliberations in entomology. The ninth SRC meeting was conducted at the Regional Station, Vittal, during 4-7 July. The projects in genetics, plant breeding, and plant physiology were discussed. The Annual Research Council meeting was held at Kasaragod during 19-22 October to review work in all the disciplines and to finalise the technical programme of work for 1974. Dr. N. G. Perur, Director of Instruction (Agri), University of Agricultural Sciences, Hebbal, Bangalore, presided over the session on soil chemistry and Shri P. V. Gajapathi Raju, Chairman, Coconut Development Council, presided over the plenary session. Shri L. R. Madhusudhan, representing the Indian Spices Export Promotion Council, Cochin, Shri T. T. Paulose, Director, Arecanut and Spices Directorate, Calicut, Shri V. K. Karthikeyan, representing the Kerala State Department of Agriculture, and Dr. P. K. Narayanan Nambiar of the Kerala Agricultural University attended the meeting. A group meeting was held on 5 November under the chairmanship of Dr. I. C. Mahapatra, Project Co-ordinator, All India Co-ordinated Agronomic Experiments, I. A. R. I., New Delhi, to discuss and review the agronomy and soil science experiments.

A group meeting was held on 31 May at Kasaragod to review the cashew research in progress at the Institute. Similarly, the pepper research programme was reviewed at a group meeting held at the Pepper Research Station, Panniyur, Kerala on 1 June. A group meeting of the cardamom research workers was held for the same purpose at the Regional Research Station, UAS, Mudigere, Karnataka, on 12 December.

The Study Circle at Kasaragod met on 28 occasions. Eleven scientific papers were presented and discussed, and 12 members presented seminars. Nineteen distinguished visitors addressed the Study Circle. The Study Circle also organized a series of special lectures on statistics.

At the Regional Station, Kayangulam, 18 meetings of the Study Circle were held. During these meetings, 13 reviews, seven special lectures, and three scientific papers were discussed. Seven distinguished scientists addressed the Study Circle. At the Regional Station, Vittal, the Study Circle met 22 times.

A farmers' meet was celebrated at Kasaragod from 30 October to 2 November. It was inaugurated by Shri N. N. Wanchoo, His Excellency the Governor of Kerala, at a meeting presided over by Shri H. A. Schamnad, Member, Rajya Sabha.

The working of the Kidu Farm, Subramanya, was inaugurated on 14 April by Shri K. Sankara Alva, Hon' ble Minister for Co-operation, Karnataka State. Padmashri T. M. A. Pai presided over the meeting.

The Cashew Seed Farm, Puttur, was inaugurated on 10 November by Shri K. H. Patil, Hon' ble Minister for Agriculture and Forests, Karnataka State at a meeting presided over by Shri K. Sankara Alva, Hon'ble Minister for Co-operation, Karnataka State. The land required for both the elite seed gardens are being made available by the Government of Karnataka.

The Institute was represented in the Coconut Development Council, Arecanut Development Council, Spices Development Council, Cashew Development Council, Cardamom Board, the Spices Export Promotion Council, and the Cashew Export Promotion Council. Senior scientists of the Institute participated in the meetings of these bodies, and the Institute continued to work in close collaboration with these councils.

Shri M. K. Muliyar, Extension Agronomist, and Dr. P. K. R. Nair, Agronomist (Soils) were deputed from 15 May to 15 August to attend the "upgrading course in the field of agricultural co-operatives" organised by the German Democratic Republic at the Agricultural Engineers' School near Leipzig.

Shri K. V. Ahamed Bavappa, Director, Shri M. C. Nambiar, Project Co-ordinator and Dr. K. U. K. Nampoothiri, Geneticist participated in the second SABRAO conference held at Delhi during 22–28 February and presented two papers at the Symposium. Shri K. V. A. Bavappa acted also as chairman of the session on plantation crops.

Dr. P. K. Koshy, Nematologist, participated in the All India Nematology Workshop held at New Delhi during 27–29 March and presented two papers on nematological investigations on coconut in Kerala and on nematodes of coffee, tea, pepper, cardamom, and other plantation crops. Dr. Koshy also attended a short term course on Recent Advances on Nematological Techniques at the University of Agricultural Sciences, Bangalore, held during 16–23 July.

Shri E. V. Nelliat, Head of the Division of Agronomy, attended the fifth combined Annual Workshop on Soil Salinity and Water Management at Hissar during 24–29 September and presented a note on the effect of sea water irrigation on coconut. He also attended the Annual Coconut Research Workers Conference of the Kerala Agricultural University held at Trivandrum on 25 June and a meeting at Bangalore on 10 April, of the plantation crops research workers and representatives of the fertilizer industry to consider the future fertilizer production trends in the country *vis a vis* the needs of the plantation crops.

Shri M. V. George, Senior Statistical Assistant, attended a Summer Institute in Design and Analysis of Agricultural Experiments and Training in Computor Programming at the IARS, New Delhi, held during 6 May–4 July.

At the Regional Station, Kayangulam, Dr. V. Harihara Subramanian, Joint Director and Dr. (Mrs.) K. Radha, Plant Pathologist attended the meeting held at the Rubber Research Institute of India, Kottayam, to discuss about the additional quarantine measures which require to be adopted to prevent the entry of the South American leaf blight disease to south east Asia. Dr. Chandy Kurian, Entomologist, participated in the group discussions on pesticides held at the Central Plant Protection Training Institute, Hyderabad, during 28–30 June.

At Vittal, Shri K. Shama Bhat, Agronomist attended the Combined Workshop on Co-ordinated Projects on Agronomic Experiments and Long Term Fertilizer Experiments organized at the Tamil Nadu Agricultural University, Coimbatore, during 24–29 January. Dr. A. R. Mohapatra, Junior Chemist, attended a symposium on acid sulphate and other acid soils of India organized jointly by the ICAR and the Indian Society of Soil Science at the Kerala Agricultural University, Vellayani, Trivandrum, during 5–10 February. Shri T. Prem Kumar, Senior Research Assistant, participated in a short term course in Insect Chemosterilents organized by the University of Agricultural Sciences, Bangalore, under the sponsorship of a UNDP/ICAR/UAS project during 19–25 February. Shri N. T. Bhat, Senior Research Assistant, participated in a Summer Institute on Instrumentation Techniques in Plant and Soil Analysis at the University of Agricultural Sciences, Bangalore, from 4 May – 3 June.

PERSONNEL

Retirements, promotions, and transfers

At Kasaragod Sri K. Satyabalan rejoined as Assistant Botanist after completing his assignment with the Government of Fiji. Sri A. Ramachandran Potti, Section Officer, Office of the Accountant General, joined as Accounts Officer relieving Sri K. T. Abubacker. Kum. C. B. Kamala Devi was promoted as Senior Research Assistant (Chemistry). Sri Chacko Mathew, Senior Research Assistant (Physiology) was, on request, reverted to his original post at Regional Station, Kayangulam. Sri M. Paul Mathew, Senior Research Assistant (Agronomy) was relieved on his resigning the post.

At the Regional Station, Kayangulam, Dr. V. Hariharasubramanian assumed charge as Joint Director and relinquished charge of the post subsequently. Sri K. Balakrishna Pillai joined as Accounts Officer succeeding Sri A. Mohammed Haneefa.

At the Regional Station, Vittal, Sri K. M. Mathai, Administrative Officer was relieved to take up a similar appointment at the CRRI, Cuttack, and Sri D. Divakara Panicker, Assistant, Regional Station, Kayangulam, was appointed to the post on *ad hoc* basis. Sri K. V. Subba Rao, Section Officer, Office of the Accountant General, Karnataka, joined as Accounts Officer in the place of Sri P. N. Ramadas. Sri K. B. Abdul Khader, Research Assistant (Agronomy) rejoined after availing leave for post-graduate studies. He was promoted as Senior Research Assistant (Agronomy). Sri M. Achuthan Nair, Senior Research Assistant (Agronomy) was transferred to the Substation, Kannara. Sri S. R. Raghavendra, Senior Library Assistant (Grade II) was relieved consequent on his appointment in the Department of Space, Bangalore.

Shri C. Devaraju, Research Assistant (Chemistry) resigned.

At Substation, Hirehalli, Shri B. Nagaraj, Research Assistant (Agronomy) was transferred to the Regional Station, Vittal.

STAFF

KASARAGOD

Director	Shri K. V. Ahamed Bavappa
Project Co-ordinator *cum* Breeder (All India Co-ordinated Spices and Cashewnut Improvement Project)	Shri M. C. Nambiar
Junior Scientific Officer	Shri K. Kunhikrishnan

GENETICS

Head of the Division	Vacant
Geneticist	Dr. K. Unnikrishnan Nampoothiri
Systematic Botanist	Vacant
Biometrician	Vacant
Assistant Botanists	1. Shri K. Satyabalan
	2. Shri R. Vasudevan Pillai
Assistant Cyto-anatomist	Vacant
Senior Research Assistants	1. Smt. P. K. Thankamma Pillai
	2. Shri C. K. Sukumaran
	3. Shri G. Vijayakumar
	4. Vacant
Senior Library Assistant	Shri C. P. Mamoo Koya
Photographer	Shri K. R. Prabhakar
Research Assistants	1. Shri K. Vellaichamy
	2. Shri A. A. Mohamed Sayed

AGRONOMY

Head of the Division	Shri E. V. Nelliat
Agronomist (Soil)	Dr. P. K. R. Nair
Junior Soil Physicist	Vacant
Farm Superintendent	Shri Rama Varma
Stores Officer	Vacant
Assistant Agronomist	Vacant
Senior Farm Assistant	Vacant
Senior Research Assistants	1. Vacant
	2. Vacant
	3. Vacant
	4. Vacant
Farm Assistant	Shri C. A. Kunhiraman
Research Assistant (Meteorology)	Shri T. K. Balakrishnan

EXTENSION

Senior Scientist (Extension & Economics)	Vacant
Extension Agronomist (Training)	Shri M. K. Muliyar
Junior Extension Agronomist	Vacant
Assistant Agronomist (Production)	Vacant
Senior Research Assistants	1. Shri C. P. Radhakrishnan Nair
	2. Shri K. J. Antony
Nursery Assistant	Shri K. Shambu
	Vacant since 14-2-73

CHEMISTRY

Senior Scientist (Soil Science)	Vacant
Soil Chemist	Shri N. G. Pillai
Biochemist	Vacant
Assistant Chemist	Shri M. P. Sankara Narayanan
Senior Research Assistants	1. Shri C. K. Balakrishnan Nambiar
	2. Kum. C. B. Kamala Devi
	3. Vacant
Senior Research Assistant (Biochemistry)	Vacant
Research Assistants	1. Shri P. Abdul Wahid
	2. Vacant
Cartographic Assistant	Shri M. Mohammed

PHYSIOLOGY

Physiologist	Dr. A. Ramadasan
Senior Research Assistant	Shri Chacko Mathew
Research Assistant	Vacant

PATHOLOGY

Plant Pathologist	Dr. K. K. Narayanan Nambiar
Senior Research Assistant	Shri Y. Ramalinga Sarma

ENTOMOLOGY

Entomologist	Shri G. Bhaskaran Pillai
Assistant Parasitologist	Vacant
Senior Research Assistant	Shri V. A. Abraham

STATISTICS

Junior Statistician	1. Shri Jacob Mathew
	2. Vacant
Senior Statistical Assistant	Shri M. V. George
Statistical Assistant	Vacant

ENGINEERING

Mechanical Engineer	Vacant
Foreman	Shri K. Karunakaran Nambiar
Mechanic (Instrument)	Vacant

TECHNOLOGY

Senior Scientist	Vacant
Design Engineer	Vacant

SCHEME FOR IMPROVEMENT OF CACAO

Junior Horticulturist	Vacant
Senior Research Assistant	Smt. M. Leela

ADMINISTRATION

Administrative Officer	Shri P. James Abraham
Assistant Administrative Officer	Shri N. D. Chakiar
Assistants	1. Shri A. V. Bhaskaran
	2. Kum. Jane Lewis
	3. Shri M. Madhavan
	4. Shri P. S. Sudarsanan

Junior Accountant	Shri S. Somasekharan Nair
P. A. to Director	Shri K. Narayana Naik
Stenographers	1. Shri V. F. John Sylvester
	2. Shri A. Keshava Shabaraya
	3. Shri T. K. Narayanan

AUDIT AND ACCOUNTS

Accounts Officer	Shri A. Ramachandran Potty
Assistants	1. Shri M. A. Ismail
	2. Smt. N. K. Ammukutty
	3. Shri N. Govinda Pillai (In the leave vacancy of Smt. P. K. Ratnam)

REGIONAL STATION, KAYANGULAM

Joint Director	Vacant

PLANT PATHOLOGY

Plant Pathologist	Dr. K. Radha
Virologist	Dr. P. Shanta
Junior Virus Entomologist	Shri K. Mathen
Assistant Plant Pathologist	Vacant
Assistant Virus Pathologist	Vacant
Senior Research Assistants	1. Smt. V. G. Lilly
	2. Shri Thomas Joseph
	3. Shri N. Gopinathan Pillai
Research Assistants	1. Smt. Elizabeth George
	2. Kum. M. Sasikala

ENTOMOLOGY

Entomologist	Dr. Chandy Kurian
Junior Parasitologist	Shri J. Antony
Assistant Parasitologist	Vacant

Assistant Toxicologist	Vacant
Senior Research Assistants	1. Shri C. P. Ramachandran
	2. Smt. B. Sathiamma
Research Assistants	1. Kum. K. N. Ponnamma
	2. Shri K. M. Abdulla Koya

PHYSIOLOGY

Assistant Plant Physiologist	Vacant
Senior Research Assistant	Shri Thomas Varkey
Research Assistants	1. Shri K. J. Michael
	2. Smt. B. Sumathykutty Amma

CHEMISTRY

Assistant Soil Chemist	Shri P. L. Ramanandan
Senior Research Assistant	Shri Robert Cecil
Research Assistants	1. Shri A. S. Mathew
	2. Smt. P. G. Kamalakshy Amma

STATISTICS

Statistical Assistant	Vacant

FARM

Assistant Farm Superintendent	Shri K. N. Sahasranaman
Farm Assistant	Shri T. G. George (on study leave)

EXTENSION

Junior Extension Agronomist	Shri K. Sethumadhava Menon
Senior Research Assistant	Shri K. J. Thommen

MICROBIOLOGY

Plant Pathologist (Microbiology)	Dr. N. P. Jayasankar
Senior Research Assistant	Shri K. V. Joseph
Research Assistant	Shri V. P. Potti

BIOCHEMISTRY

Junior Biochemist	Vacant

NEMATOLOGY

Nematologist	Dr. P. K. Koshy

LIBRARY

Senior Library Assistant (Gr. II)	Shri M. Divakaran Pillai

ADMINISTRATION

Administrative Officer	Shri V. Somanathan
Superintendent	Shri P. K. Raghavan
Assistants	1. Shri M. Mathews
	2. Shri M. Ravi
	3. Vacant

AUDIT AND ACCOUNTS

Accounts Officer	Shri K. Balakrishna Pillai
Assistants	1. Shri P. V. Shanmukhan
	2. Shri U. Sukumaran
	3. Shri T. K. Abdulkharim

REGIONAL STATION, VITTAL

Joint Director (Breeder)	Dr. N. M. Nayar

GENETICS

Geneticist	Dr. M. K. Nair
Breeder	Shri K. Narasimha Murthy
Assistant Botanist	Vacant
Senior Research Assistants	1. Shri P. M. Kumaran
	2. Vacant
	3. Vacant
Research Assistant	Smt. M. J. Ratnambal

AGRONOMY

Agronomist	Shri K. Shama Bhat
Assistant Agronomist	Vacant
Senior Research Assistants	1. Shri K. B. Abdul Khader
	2. Vacant
Farm Superintendent	Vacant
Senior Farm Assistant	Shri M. Vijayarajan
Research Assistants	1. Shri B. Nagaraj
	2. Vacant
Farm Assistant	Vacant
Nursery Assistant	Vacant

CHEMISTRY

Biochemist	Vacant
Junior Chemist	Dr. A. R. Mohapatra
Assistant Chemist	Vacant
Senior Research Assistants	1. Shri N. Tirumaleshwar Bhat
	2. Vacant
Research Assistant	Vacant

PHYSIOLOGY

Assistant Plant Physiologist	Vacant
Research Assistants	1. Shri C. K. Mathai
	2. Vacant

PLANT PATHOLOGY

Assistant Plant Pathologist	Vacant
Senior Research Assistants	1. Shri R. Radhakrishnan Nair
	2. Kum. N. Saraswathi

ENTOMOLOGY

Assistant Entomologist	Vacant

Senior Research Assistant	Shri T. Prem Kumar
Research Assistant	Kum. Mariamma Daniel

STATISTICS

Assistant Statistician	Vacant
Computor	Shri K. Vijayakumar

LIBRARY

Senior Library Assistant (Grade II)	Vacant

ADMINISTRATION

Administrative Officer	Shri D. Divakara Panicker
Superintendent	Vacant
Assistants	1. Kum. H. Shrimanthini Bai 2. Shri P. Gangadharan

AUDIT AND ACCOUNTS

Accounts Officer	Shri K. V. Subba Rao
Assistant	Shri N. T. Prabhakaran
Junior Accountant	Shri P. Velayudhan Nair

SUBSTATION, KANNARA

Junior Agronomist	Dr. C. K. George
Assistant Agronomist	Vacant
Senior Research Assistant	Shri M. Achuthan Nair
Research Assistant	Vacant

SUBSTATION, PALODE

Breeder (Oil Palm)	Vacant
Junior Pathologist	Shri T. S. S. Rawther
Assistant Agronomist	Shri K. J. Abraham

Senior Research Assistant (Botany)	Shri R. S. N. Pillai
Senior Research Assistant (Agronomy)	Vacant
Farm Assistant	Shri K. K. Krishnan Nambiar

SUBSTATION, HIREHALLI

Assistant Agronomist	Shri M. Sannamarappa
Research Assistants	1. Shri S. N. Sampath Kumar
	2. Vacant
Farm Assistant	Shri T. Kempanna

SUBSTATION, MOHITNAGAR

Assistant Agronomist	Vacant
Senior Research Assistant	Shri Rakshit Narayana Brahma
Research Assistant	Shri Ramkeshwar Singh
Farm Assistant	Vacant

SUBSTATION, KAHIKUCHI

Assistant Agronomist	Shri Asish Ranjan Roy
Research Assistants	1. Shri Asish Kumar Roy
	2. Vacant
Farm Assistant	Shri Mahavir Singh

SUBSTATION, ANDAMANS

Junior Agronomist	Shri A. K. Sadanandan
Assistant Breeder	Shri R. Balakrishnan Nair

KIDU FARM, SUBRAMANYA, NETTANA POST

Breeder	Vacant
Junior Plant Pathologist	Vacant
Junior Entomologist	Vacant

Farm Superintendent	Vacant
Senior Farm Assistant	Shri A. Manjunatha Shetty

CASHEW SEED FARM, PUTTUR, SHANTIGODU POST

Horticulturist	Vacant
Junior Plant Pathologist	Vacant
Farm Superintendent	Vacant
Senior Research Assistants	1. Vacant
	2. Vacant