VISION - 2020

Directors office

CPCRI

PERSPECTIVE PLAN

CPCRI

GOLDEN JUBILEE YEAR OF INDIA'S INDEPENDENCE
ICAR
1947-1996

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

VISION - 2020

CPCRI
PERSPECTIVE PLAN

CPCRI

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
[INDIAN COUNCIL OF AGRICULTURAL RESEARCH]
KASARAGOD - 671 124, KERALA

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May, 1997

Printed at

Code Word Process & Printers,
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FORE WORD

Over the years, the Indian Agricultural Research System under the aegis of the Indian Council of Agricultural Research has served a very useful purpose. Nevertheless, in the fast changing global context, managing the change on a time scale, by converting weakness, if any, into opportunities to become internationally competitive is considered important. We need to be forward looking and visible with appropriate agricultural research policies in place supported by the cutting edge technologies in order to attain and sustain global advantages. In this background the formulation of a perspective plan with a visionary approach for the next 25 years becomes quite necessary. The clearly spelt out options and likely changes would enable the system to capitalize on our strength so that the threats, if any, are converted into opportunities.

The country has made rapid strides in the production and productivity of plantation crops like coconut and arecanut during the last few decades. The Central Plantation Crops Research Institute (CPCRI), with its chequered history spanning over a period of eight decades had played a pivotal role in R & D of coconut, arecanut and cocoa. As we enter the 21st century, it is essencial for us to analyze our successes and failures and develop a strategic plan for the future.

The Perspective Plan of the CPCRI is a step in this direction which identifies our strength and weaknesses in coconut and arecanut culture and outlines future R & D strategies by identifying programmes and reprioritising the existing projects to develop sustainable production systems. I hope the programmes envisaged in the document will be successfully executed and will go a long way in improving production and productivity to meet the ever increasing demands.

In perspective plan formulation there was an overwhelming response to Council's initiative. The staff of the Policy and Planning Cell of the Council deserves all appreciation for under taking this onerous task right from designing of the necessary format and taking the plan formulation process to its logical conclusion. The various divisional heads at the ICAR Headquarters, Peer Review and RAC members made valuable contributions to the process of Plan formulation. The Director and Scientists of the institute have put in their collective wisdom in bringing out the document in its present form. It is hoped that the framework prepared would continue to be reviewed to accommodate changes in future so that the perceived vision continues to be close to the expected target. In the years to come, based on the long term perspective, it would be relevant to put implementable plan to action on five yearly basis to match with the on going planning system of the country.

(R. S. PARODA)
Secretary, DARE and
Director General, ICAR

March 5, 1997

INTRODUCTION

The Central Plantation Crops Research Institute established in 1970 had in the initial years, a mandate of crop improvement in coconut, arecanut, oil palm, cocoa, cashew and spices through basic and applied research. Next one and a half decades witnessed consolidation and expansion of areas of research and also establishment of new centres to meet the changing research requirements. However restructuring and delinking process started during the VII Five Year Plan and the research on spices and cashewnut were delinked from CPCRI to establish separate National Research Centres. ICAR Research Complex for Goa was also delinked from CPCRI.

At present the Institute has a country-wide research network of 10 centres besides the Headquarters at Kasaragod to cater to the research needs of palms and cocoa under varying agro-climatic conditions. Some of the outstanding research achievements of the Institute during the last 25 years are, evolving three high yielding coconut hybrids and three varieties, four high yielding varieties in arecanut, production of indigenous *tenera* hybrids in oilpalm for the first time in the country, standardizing coconut based farming system to increase the income from unit area, establishing the etiology of root (wilt) disease and preliminary success in evolving a disease tolerant coconut variety, standardizing input requirements and plant protection measures for coconut, arecanut, cocoa and oilpalm, contributing to self-sufficiency in arecanut production in the country and developing a protocol for coconut embryo culture.

In the Perspective Plan of CPCRI presented in the following pages we have attempted to realistically look into the achievements made in the past and aim to develop modern technologies which will contribute to increase the production and productivity of coconut, arecanut and cocoa. The rapidly changing advancement in propagation techniques, biotechnological aspects and their application, modifying concept of crop improvement with minimum input and maximum productivity have been analysed and presented. The final out come of this Perspective Plan is the base work on the draft prepared by the Scientists of this Institute which was discussed and modified at the Institutional level. The recommendations of the Peer Review Committee members and Research Advisory Committee members were incorporated subsequently.

We would like to keep on record the valuable contribution by way of advice and suggestion made by Dr. R.S. Paroda, Secretary DARE and Director General, ICAR and Dr. K.L. Chadha, the then Deputy Director General (Hort.) which greatly contributed to refining and polishing the Plan. We would like to express our deep felt gratitude to Dr. R.S. Paroda for his stimulating Foreword to this Perspective Plan.

(M. K. NAIR)
Director, CPCRI

May 26, 1997

LIST OF ABBREVIATIONS USED

AICRP	-	All India Co ordinated Research Project
AICRPP	-	All India Co ordinated Research Project on Palms
APAU	-	Andhra Pradesh Agricultural University
APCC	-	Asia and Pacific Coconut Community
CDB	-	Coconut Development Board
CGD	-	Chowghat Green Dwarf
CGR	-	Compound Growth Rate
CIAE	-	Central Institute for Agricultural Engineering
CFTRI	-	Central Food Technology Research Institute
COD	-	Chowghat Orange Dwarf
COGENT	-	Coconut Genetics Resources Network
CPCRI	-	Central Plantation Crops Research Institute
CSIR	-	Council for Scientific and Industrial Research
d	-	dura
DBT	-	Department of Biotechnology
D X T	-	Dwarf X Tall
FAO	-	Food and Agricultural Organization
FFB	-	Fresh Fruit Bunch
IBPGR	-	International Board of Plant Genetic Resources
ICAR	-	Indian Council of Agricultural Research
IPGRI	-	International Plant Genetic Resources Institute
IPM	-	Integrated Pest Management
IRHO	-	Institut fur recherche pour les huiles et Oleagineaux
KAU	-	Kerala Agricultural University
LO	-	Laccadive Ordinary
NARP	-	National Agricultural Research Project
NBPGR	-	National Bureau of Plant Genetic Resources
NICNET	-	National Informatics Centre Net Work
ODNRI	-	Overseas Development and Natural Resources Institute
p	-	pisifera
PCA	-	Philippines Coconut Authority
RAC	-	Research Advisory Committee
RAPD	-	Random Amplified Polymorphic DNA
RFLP	-	Restriction Fragment Length Polymorphism
RRL	-	Regional Research Laboratory
RWD	-	Root Wilt Disease
T X D	-	Tall X Dwarf
T X T	-	Tall X Tall
TNAU	-	Tamil Nadu Agricultural University
UAS	-	University of Agricultural Sciences
USAID	-	United States Agency for International Development
VAM	-	Vesicular Arbuscular Mycorrhizae
WCGC	-	World Coconut Germplasm Centre
WCT	-	West Coast Tall
YLD	-	Yellow Leaf Disease

EXECUTIVE SUMMARY

The Central Plantation Crops Research Institute has the mandate of developing appropriate production, protection and processing technologies for coconut, arecanut and cocoa after delinking research on spices, cashew and oil palm from the Institute. It also coordinates, on all India level, the research on palms (coconut, oil palm and palmyrah) and make efforts to transfer high production technologies to the farmers and extension agencies. The Institute has a sanctioned staff strength of 949 including 113 scientists and the budget provided during the VIII plan period is about Rs.30 crores.

The Institute has one of the largest germplasm depositories of coconut (132 accessions), arecanut (68 accessions) and cocoa (94 accessions). The Institute has evolved and released three hybrids and two high yielding varieties in coconut and four high yielding arecanut varieties. The input technologies for palms and palm based cropping systems such as nutrient and water requirement have been developed. Plant protection measures against important diseases and pests of coconut, arecanut and cocoa have been evolved. The Institute also concentrates on simplifying the post harvest processing technologies for these crops. The nucleus planting materials in coconut, arecanut and cocoa are produced at the Seed Farm of the Institute located in Karnataka for distribution to Developmental Departments and farmers.

The Perspective Plan of the Institute given in the following pages aims to develop technologies for increasing production and productivity of coconut, arecanut and cocoa. Among the research programmes envisaged during the next 25 years, the most important ones are: developing coconut varieties tolerant to root(wilt) disease and drought; establishing a regional gene bank of coconut under CPCRI which will cater to the needs of South Asian countries; evolving a dwarf, high yielding arecanut variety; strengthening the biotechnology laboratory for perfecting clonal propagation of coconut and also in-depth studies on biochemical aspects using latest techniques like RFLP/RAPD markers; developing palm based farming systems with minimum input of nutrients and water to maximize net returns from unit area; developing a organic farming system for palms and cocoa; indexing techniques for important diseases of palms; updating data on crop loss due to pests and diseases; establishing a pesticide residue laboratory and effective utilization of coconut timber by developing appropriate processing techniques. The transfer of technology programme is also proposed to be strengthened by Institute-Village Linkage Programme, conducting training courses and dissemination of technologies through audio-visual methods.

CONTENTS

1. PREAMBLE

In India, coconut, arecanut, and spices are cultivated by individual land owners since time immemorial, but cultivation of these crops was not organized to the same extent as in the case of plantation crops like tea, coffee and rubber till the middle of the twentieth century. Increase in production of coconut, arecanut and spices were due to the increased area under cultivation and the productivity remained static or sometimes even showed a downward trend. Research efforts were not forthcoming for increasing the productivity of these group of crops till the late 50s except perhaps for coconut. It is in this context that the research on agricultural plantation crops was unified in 1970 by the Indian Council of Agricultural Research and the Central Plantation Crops Research Institute was established with its Headquarters at Kasaragod. The Institute was established by merging the erstwhile Central Coconut Research Station, Kasaragod, Central Coconut Research Station, Kayangulam and the Central Arecanut Research Station, Vittal along with its five sub-stations at Palode and Peechi (Kerala), Hirehalli (Karnataka), Mohitnagar (West Bengal) and Kahikuchi (Assam).

In the initial years of establishment, the mandate of the Institute was limited to crop improvement in coconut, arecanut and cocoa through basic and applied research. Adaptive research on cashew and spices was undertaken w.e.f. 1971 with the establishment of All India Co-ordinated Spices and Cashewnut Improvement Project. Subsequently, the All India Co-ordinated Coconut and Arecanut Improvement Project (AICCAIP) started functioning from 1972 with its headquarters at CPCRI, Kasaragod.

The next one and a half decades were devoted to consolidating and expanding the area of research and also in establishing newer centres to meet the requirement of changing mandate. The period witnessed the establishment of a Seed Farm at Kidu (Karnataka) in August 1972 to produce quality planting materials in coconut, arecanut and cocoa, a Seed Farm for cashew at Shantigodu (Karnataka), acquiring the Research Centre at Appangala (Karnataka) for cardamom research in 1974, establishing a Regional Station at Calicut (Kerala) in 1975 for conducting research on spices, establishing a Field Station at Irinjalakkuda (Kerala) to monitor the northward spread of coconut root(wilt) disease, initiating research on oil palm at CPCRI Research Centre, Palode and taking over the administrative control of ICAR Research Complexes at Goa and Lakshadweep Island. To meet the added responsibility of research, the expansion of the Institute in terms of infrastructural facilities, and scientific and other staff strength was also made. The period also witnessed many outstanding research achievements in terms of releasing high yielding coconut hybrids, standardizing coconut based farming systems to increase the income of the farmer from the unit area, achieving self-sufficiency in arecanut, management of coconut root (wilt) disease affected gardens, production of indigenous *tenera* hybrids in oil palm, standardizing input requirement for coconut, arecanut and spices, and releasing high yielding varieties in black pepper and turmeric.

While the period from 70s to mid 80s were the years of development and reorganization of Institute and consolidation of research programmes, in the later half of 80s, CPCRI adopted the role of a mother Institute in establishing National Research Centres. During 1986 (VII Five Year Plan) research on spices and cashew was delinked from the Institute with the establishment of National Research Centres at Calicut and Puttur respectively, mostly by redeployment of scientists and staff from CPCRI. Simultaneously the All India Co-ordinated Cashewnut & Spices Improvement Project was bifurcated and the project on spices was transferred to Calicut and that of cashew to Puttur.

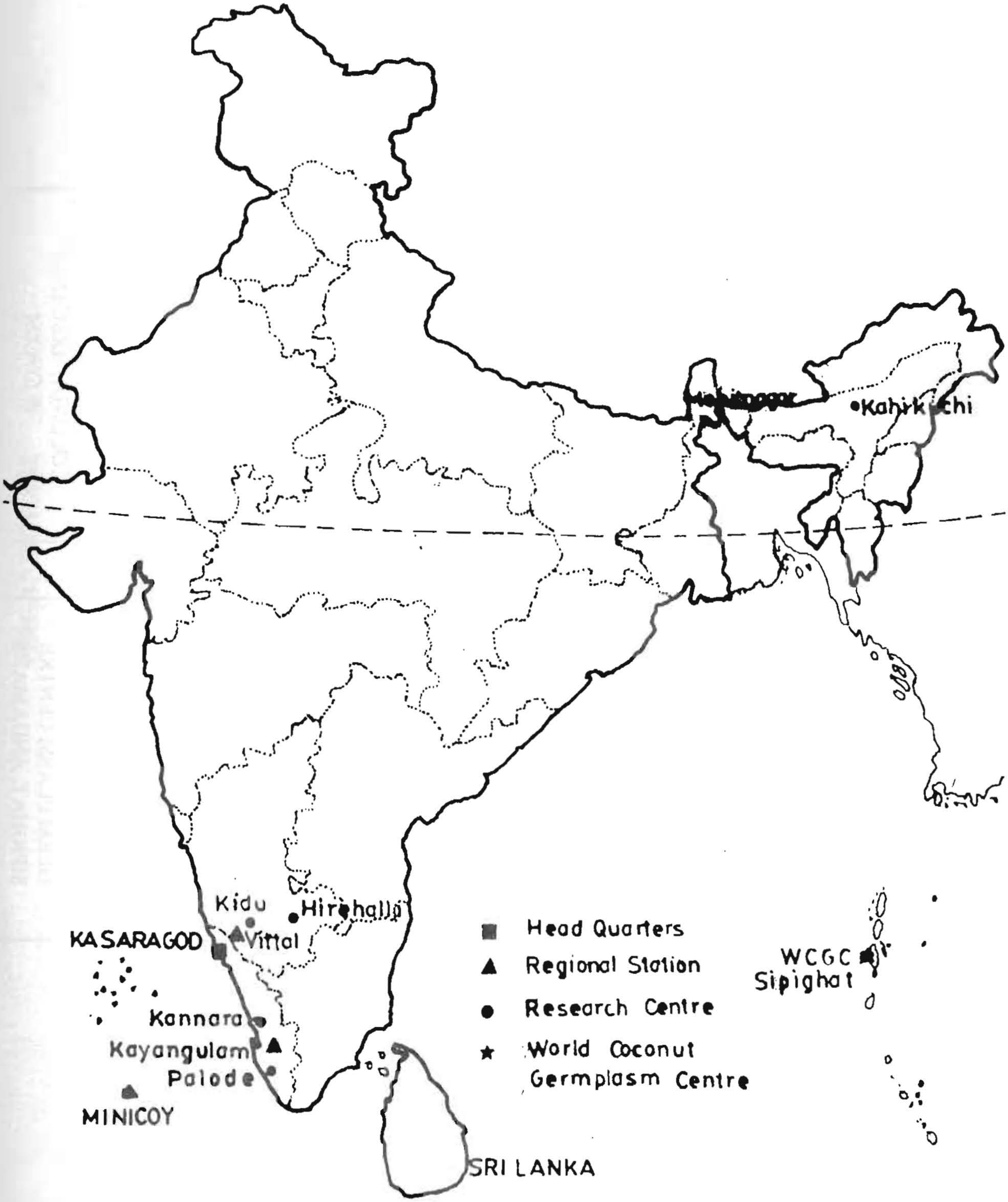
Further, arecanut was excluded from the ambit of the AICCAIP and in its place oilpalm was included and the project was renamed as All India Co-ordinated Research Project on Palms (AICRPP). Later, palmyrah palm (Borassus flabellifer) was also included in the Project. During 1989 the ICAR Research Complex for Goa was upgraded as an independent Institute, delinking it from CPCRI. A Krishi Vigyan Kendra was also established at Kasaragod during 1993 for effective transfer of technology to the farming community.

During the early 90s, the country faced serious shortage of edible oil. The Institute had already explored the feasibility of growing oil palm commercially and generated the required back-up support to oil palm research at Palode Research Centre. Having established the potential of the oil palm in the country, the Council decided to establish a separate National Research Centre for Oil Palm and the same started functioning at Pedavegi (Andhra Pradesh) from March 1995.

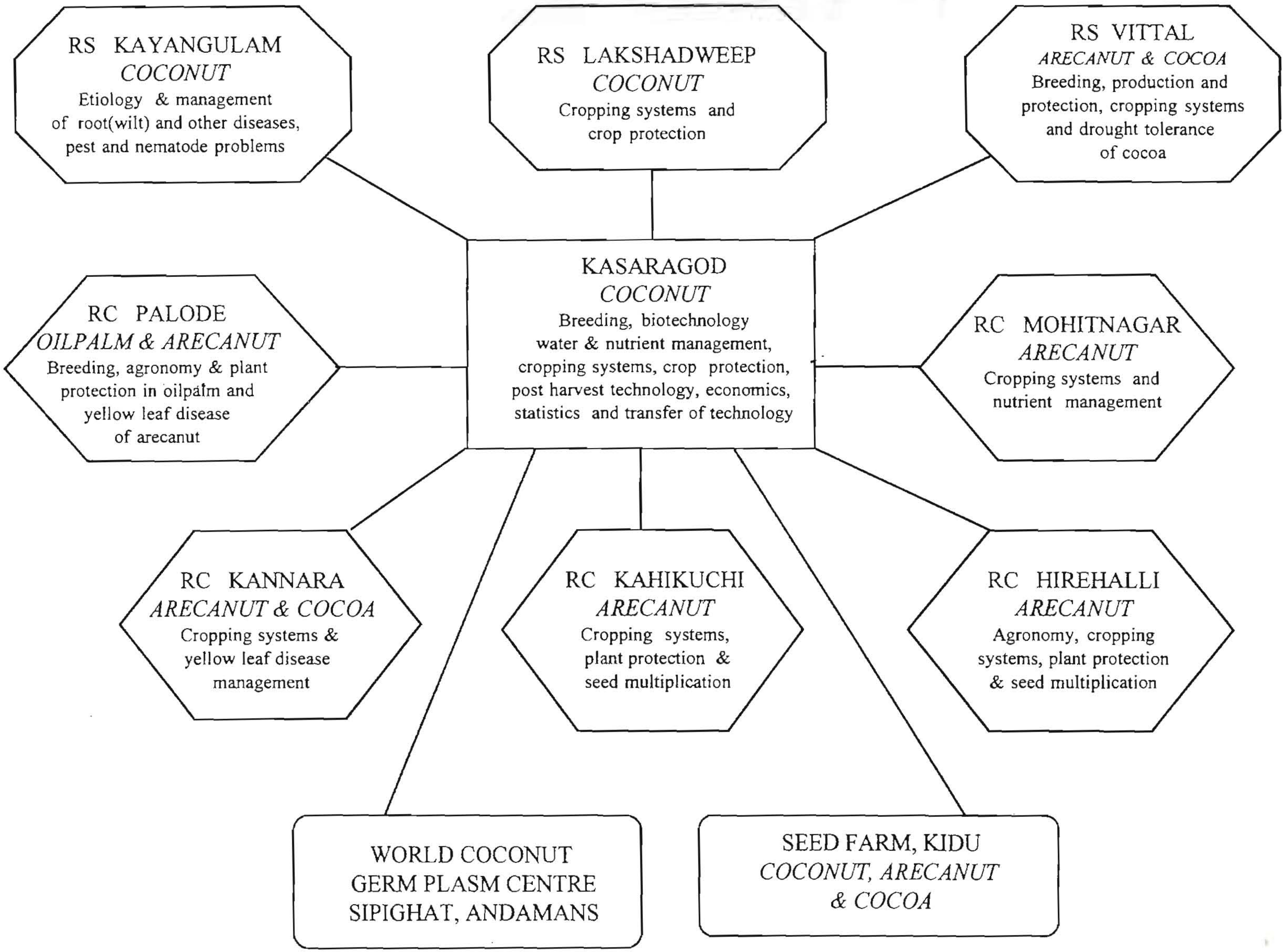
The later half of 80s and early 90s also witnessed expansion of the research programmes particularly in the field of biotechnology, Phytoplasma diseases of palms, organic farming, cropping systems, drought tolerance and many other frontiers modern agricultural science.

Taking into account the gains made so far and the role CPCRI has played in establishing three National Research Centres, we would like to look into the future by fixing the new goals and objectives which this document tries to outline.

MAP SHOWING LOCATION OF CENTRES UNDER CENTRAL PLANTATION CROPS RESEARCH INSTITUTE



CROPS AND PROBLEMS INVESTIGATED AT DIFFERENT CENTRES



ORGANOGRAM

DIRECTOR

DIVISION OF CROP IMPROVEMENT
- Biotechnology
- Genetics & cytogenetics
- Plant breeding
- Economic Botany
- Horticulture

DIVISION OF CROP PRODUCTION
- Agronomy
- Soil science
- Soil micro biology

DIVISION OF CROP PROTECTION
- Entomology
- Pathology
- Nematology

DIVISION OF PHYSIOLOGY BIOCHEMISTRY & TECHNOLOGY
- Plant physiology
- Biochemistry
- Agrl. Engineering
- Electronics & Instrumentation

DIVISION OF SOCIAL SCIENCES
- Economics
- Extension
- Statistics

KRISHI VIGYAN KENDRA

Project Co-ordinator

AICRP on Palms

COCONUT
- Ambajipeta-APAU
- Aliyarnagar-TNAU
- Arsikere-UAS(B)
- Jagadalpur-IGKVV
- Jalalgarh-RAU
- Kahikuchi-AAU
- Mondouri-BCKVV
- Konark-OUAT
- Ratnagiri-KKV
- Veppankulam-TNAU

OILPALM
- Aduthurai-TNAU
- Gangavathy-UAS(D)
- Mulde-KKV
- Vijayarai-APAU

PALMYRAH
- Killikulam-TNAU
- Pandirimamidi-APAU

2. MANDATE

2.1 Original mandate

1) Conducting research in the different disciplines related to plantation crops

2) Guiding research work carried out at the different Regional and Sub Stations in the country

3) Co-ordinating work done on plantation crops by the Institutes, Universities and State Departments of Agriculture

4) Servicing the All India Co-ordinated Project on Coconut and Arecanut and Project on Cashew and Spices

5) Serving as a centre of information on all matters relating to these crops

2.2 Revised mandate as per ICAR book

1) To develop appropriate production, protection and processing technologies for coconut, oil palm, arecanut, and cocoa through basic and applied research

2) Act as a national repository for the genetic resources of these crops

3) Produce parental lines and breeders' stock of plantation crops

4) Develop improved palm-based farming systems through more effective use of natural resources to increase productivity and income from unit area

5) Collect, collate and disseminate information on the above crops to all concerned

6) Co-ordinate research on these crops within the country and execute the research programmes under the All India Co-ordinated Research Project on Palms

7) Transfer technologies developed at CPCRI to the farmers through the co-operation of Developmental Departments/Boards by sponsoring training programmes, workshops, demonstrations etc

2.3 Proposed mandate

1) Crop improvement and developing appropriate production, protection and processing technologies for coconut, arecanut and cocoa

2) Acting as a national repository for the genetic resources of the mandate crops

3) To produce parental lines and elite planting materials of coconut, arecanut and cocoa

4) Co-ordinating research under the All India Co-ordinatedResearch Project on Palms

5) Transferring appropriate technologies developed on coconut, arecanut and cocoa to the farmers by establishing linkages with the development departments.

3. GROWTH

3.1 Infrastructure

3.1.1. Laboratories

The Institute has well equipped laboratory facilities, especially at its headquarters at Kasaragod and the two regional stations at Kayangulam and Vittal. At Kasaragod, modern laboratory facilities with sophisticated instruments are available for conducting research in biotechnology, genetics and plant breeding, agronomy, soil and plant nutrition, microbiology, plant pathology, entomology, nematology, and physiology and biochemistry. In addition, there is an engineering workshop with moderate facilities for design and development of farm implements and machinery. The Institute has recently modernized the computer facilities by installing five independent PCs and Local Area Network (LAN) with six terminals distributed in different sections. The Institute is also connected to the National Network viz., NICNET with the installation of MODEM and has E mail facilities.

At the Regional Station, Kayangulam there are excellent laboratory facilities for conducting advance research in Phytoplasma with electron microscope, ultracentrifuge, ELISA reader and other related instruments. Besides, adequate facilities are there for research on biocontrol of pests. Moderate laboratory facilities are also available in other sections such as nematology, soil science, plant pathology and crop physiology. At the Regional Station Vittal, laboratories with sophisticated instruments are available for studies on crop physiology, soil and tissue analysis, pathology, entomology and biochemistry. Computer facilities have also been established in both the Regional Stations to a limited extent.

Among the research centres, Palode has facilities for conducting research in soil and tissue analysis, and investigations on plant diseases and insect pests. Besides, there is also a small scale oil extraction unit for extracting palm oil. However the laboratory facilities are available only to a very limited extent in one or two disciplines in other research centres viz., Hirehalli, Kannara, Mohitnagar and Kahikuchi. The laboratory facilities are almost non-existent at WCGC, Andamans and at Lakshadweep.

Though strenuous efforts are being made for further strengthening the laboratory facilities in various regional stations and research centres of CPCRI with the latest instruments, only limited funds were allotted for the same during the VIII plan which was enough for just replacing the old equipments, but not adequate for purchase of all the latest equipments required by the different divisions.

3.1.2. Library

The Institute has good library facilities both at its head quarters at Kasaragod and the two Regional Stations at Kayangulam and Vittal. The number of Indian and foreign journals at present subscribed in various centres is given in Table 1. On the whole, the Institute subscribes to 272 Indian and 153 foreign journals. The total number of books, back volumes and other documents available for reference in all the centres put together are 19851, 20284 and 11016 respectively. The library also provides Selective Dissemination of Information

Table 1. Library facilities at various centres

Station	Indian journals	Foreign journals	Back volumes	Books	Other documents
Kasaragod	112	85	9032	9893	5972
Kayangulam	28	35	5373	3264	2627
Vittal	43	18	5104	5275	2053
Palode	11	10	359	465	236
Mohitnagar	7	2	-	221	24
Hirehalli	9	2	416	466	13
Kahikuchi	8	1	-	43	55
Kannara	-	-	-	214	20
Kidu	24	-	-	10	16
Total	**272**	**153**	**20284**	**19851**	**11016**

services on specialized areas of research at the Institute to the scientists on request and brings out publications like Palms and Cocoa Abstracts, Palms and Cocoa Alerts, Union Catalogue of Periodical Holdings, New Additions List and Content Page Service etc. However, due to shortage of funds which is limited to 2.0 % of the Institute budget, the library has been forced to discontinue subscription to a large number of foreign journals in the recent years and could not purchase any new books during the last couple of years.

3.1.3 Field

The Institute has a total area of 390.54 ha of which 329.28 ha is the cultivable area. The area under cultivation is about 305.78 ha. The area available for planting is only 23.5 ha of which 20.0 ha is in the Kidu seed farm. At the headquarters at Kasaragod and the two Regional Stations at Kayangulam and Vittal, almost all the cultivable area has been used up and for laying out new experiments, we are cutting down palms in the plots, where experiments have been concluded even though all the palms have not reached senility. The details of land in headquarters, regional stations and rescarch centres are summarized in Table 2.

Table 2. Details of land available in different centres of CPCRI

Sl. No.	Place	Total area (ha)	Cultivable area (ha)	Area under cultivation (ha)	Area yet to be planted (ha)
01.	HQ. Kasaragod	77.86	59.50	58.00	1.50
02.	Regional Station Kayangulam	24.17	22.57	22.57	nil
03.	Regional Station Vittal	68.34	57.34	57.34	nil
04.	Regional Station Lakshadweep	6.00	5.70	5.70	nil
05.	Research Centre Palode	32.00	27.00	27.00	nil
06.	Research Centre Kannara	14.17	10.17	9.17	1.00
07.	Research Centre Hirehalli	16.00	12.50	12.50	nil
08.	Research Centre Mohitnagar	10.00	7.00	7.00	nil
09.	Research Centre Kahikuchi	12.00	10.00	10.00	nil
10.	Seed Farm Kidu	120.00	109.50	89.50	20.00
11.	WCGC, Sipighat Andamans	10.00	8.00	7.00	1.00
	Total	**390.54**	**329.28**	**305.78**	**23.50**

3.1.4. Buildings

At Kasaragod, most of the laboratories and office are located in two buildings. The Institute Main Building houses the Biotechnology, Soil Science, Entomology and Nematology laboratories, the Director's personal section, Project Monitoring and Technical section and the Statistics section. The Library, Seminar hall, Project Coordinator's (Palms) cell, Extension, Pathology, Microbiology, Agronomy and Plant Breeding sections and administration and accounts wings are accommodated in the Diamond Jubilee Building. In addition, there are also a Technology Workshop, Farm Office, Stores and a cattle shed. The Platinum Jubilee Hall of the Institute houses temporarily the Krishi Vigyan Kendra. The Institute also has three guest houses and one hostel and about 100 residential quarters of various categories. However the available space is not adequate for the laboratories and office.

At the Regional Station Kayangulam, the main building houses the Head's office, technical section, Statistics, Library and Soil Science, Nematology, Entomology, Plant Breeding and Physiology laboratories. There is also a well equipped Phytoplasma laboratory having electron microscope and related equipments as well as a biocontrol laboratory. In addition, separate buildings are existing for administration and accounts, farm office and a guest house.

At the Regional Station Vittal, the main building houses the Head's office, and Plant Pathology, Entomology, Agronomy, Crop Physiology and Biochemistry and Plant Breeding sections/laboratories. Another building caters to the needs of administration and accounts and library. The station also has a number of residential quarters, besides a guest house, farm office and stores buildings. At the Palode centre, there are separate buildings for administration, laboratory (Plant Breeding, Entomology, Pathology & training sections, and Soil Science) and Palm oil mill (which also houses the farm office). The other research centres at Mohitnagar, Kahikuchi, Hirehalli and Kannara and the Lakshadweep Regional Station at Minicoy have modest administrative cum laboratory buildings. While the farm office at Kidu Seed Farm is located in a semi permanent structure, that at WCGC Andamans is housed in a temporary shed. The centres at Kannara, Palode, Hirehalli, Mohitnagar and Kidu have a limited number of residential quarters whereas no residential accommodation is available at Lakshadweep, Andamans and Kahikuchi.

3.2. Budget (Rs. in lakhs)

Plan period	Plan	Non-plan	Total
IV Plan*	67.24	121.72	188.96
V Plan	228.26 (239.5)	226.97 (86.5)	455.23 (140.9)
Annual Plan (1979.80)	70.18	87.68	157.85
VI Plan	498.27 (118.3)	618.41 (172.5)	1116.68 (145.3)
VII Plan	355.48 (-28.6)	1230.23 (98.9)	1585.71 (42.0)
Annual Plans (90-91 & 91-92)	186.43	681.65	868.08
VIII Plan	711.55 (100.1)	2226.53 (81.0)	2938.08 (85.3)

Note: Figures in parentheses indicate percentage increase over the previous plan period

* for four years only (1970-'71 to 1973 -'74)

IX 1137.00 6360.0 7497.0

3. 3. Manpower (Sanctioned)

Plan Period	Scientific	Technical	Administration	Auxiliary	supporting
IV Plan	91	93	64	-	73
V Plan	195 (114.3)	113 (21.5)	112 (75.0)	- -	651 (791.8)
VI Plan	223 (114.3)	201 (21.5)	146 (75.0)	30 -	647 (791.8)
VI Plan	223 (14.4)	201 (77.9)	146 (30.4)	30	647 (-0.6)
VII Plan*	135 (-39.5)	150 (-25.4)	111 (-24.0)	24 (-20.0)	524 (-19.0)
VIII Plan* (upto Sep. '95)	126	166	115	26	539
VIII Plan (from Oct. 95)	113* (-16.3)	166 (10.6)	112 (0.9)	26 (8.3)	532 (1.5)

Note: Figures in parentheses indicate percentage change (increase or decrease) over the previous plan period
The manpower in VIII Plan includes KVK staff

* Reduction in manpower during VII & VIII Plans is due to redeployment to establish NRCs on Spices, Cashewnut & Oilpalm

** Discipline-wise cadre strength is given in Annexure I

4. SALIENT RESEARCH ACHIEVEMENTS

4.1 Crop Improvement

i) Gene banks:

The cultivated varieties and their relatives which are the basic raw materials for crop improvement research are being maintained in live gene banks in different centres.

The coconut germplasm repository at the Institute consists of 86 exotic and 46 indigenous accessions. This includes 24 exotic accessions collected under a FAO/IBPGR - funded expedition in 1981, which are maintained at the World Coconut Germplasm Centre, (WCGC), Andamans.

Twenty three exotic arecanut collections from 11 countries, consisting of six species of areca and 45 indigenous types are being maintained at Vittal. Germplasm collection of cocoa maintained at Vittal and Kannara centers consists of 94 accessions from four countries.

The germplasm bank of oil palm at Palode consists of 22 accessions introduced from eight countries. These include *tenera* hybrids, hybrids of deli *dura* x *pisifera,* dumpy *dura* x *pisifera*, *E.oleifera* x *E.guineensis* and the parental materials of *dura* and *E. oleifera.*

ii) Release of high yielding varieties and hybrids in coconut :

Hybrid vigour in coconut was demonstrated first in this Institute as early as 1937 and has been successfully exploited on a commercial scale. Three hybrids, which are not only early bearing but also give higher yield than either of the parents, have been released.

Systematic multilocation evaluation of indigenous cultivars culminated in the release of Laccadive Ordinary (Chandra Kalpa) and Banawali Green Round (Pratap). Chowghat Orange Dwarf has been identified as the best cultivar for use as tender nut. These varieties and hybrids have received ready acceptance by farmers of Kerala, Tamil Nadu, Andhra Pradesh, Karnataka and Goa.

iii) Crop improvement in arecanut :

Selection and release of four high yielding varieties viz., Mangala, Sumangala, Sreemangala and Mohitnagar had played a major role in increasing production and productivity in arecanut.

iv) Indigenous production of tenera hybrids in oil palm :

Till 1982 it was necessary to import the entire requirements of *tenera* oil palm hybrid seed, as the male parent *pisifera* was not known to be available in India. Since then, promising *dura* and *pisifera* palms have been located in the existing oil palm plantations in Kerala enabling the Institute to produce about three lakh *tenera* seeds annually. Two of the indigenous *tenera* hybrids viz., 65 d x 30.103 p and 120 d x 30.103 p are capable of giving yields upto 4.5 tonnes of oil/ha/year under rainfed conditions.

4.2 Crop Production

i) Palm based farming systems :

The diversified needs of farming community to produce more food, fodder and fuel from unit area, besides increasing net returns through gainful employment of family labour led to the development of palm-based cropping systems. These systems involve growing multispecies of crops that can harvest solar radiation in different tiers, in the inter spaces of coconut and arecanut gardens.

Intercropping and mixed cropping with compatible component crops in coconut and arecanut do not have any adverse effect on the yield of main crop. Added advantage is the increasing net return to the farmer.

Coconut-based intercropping involving a number of annuals, mixed cropping involving black pepper, clove and cocoa, multistoreyed cropping under irrigation involving pineapple, pepper and cocoa and mixed farming involving fodder, pepper, vegetables, milch animals, poultry, and rabbitry are some of the more successful farming systems demonstrated at the Institute.

Studies have also indicated that sustained higher levels of productivity in coconut-based cropping systems could be achieved even with the application of one-third of the recommended dose of fertilizers to the component crops by judicious recycling of the biomass produced.

ii) Coconut nutrition :

For successful establishment of coconut seedlings in littoral sandy soils, blending of organic sources like coir pith, coconut sheddings, farm yard manure, and forest leaves @ 20 kg/seedling along with chemical fertilizers has been found to be beneficial.

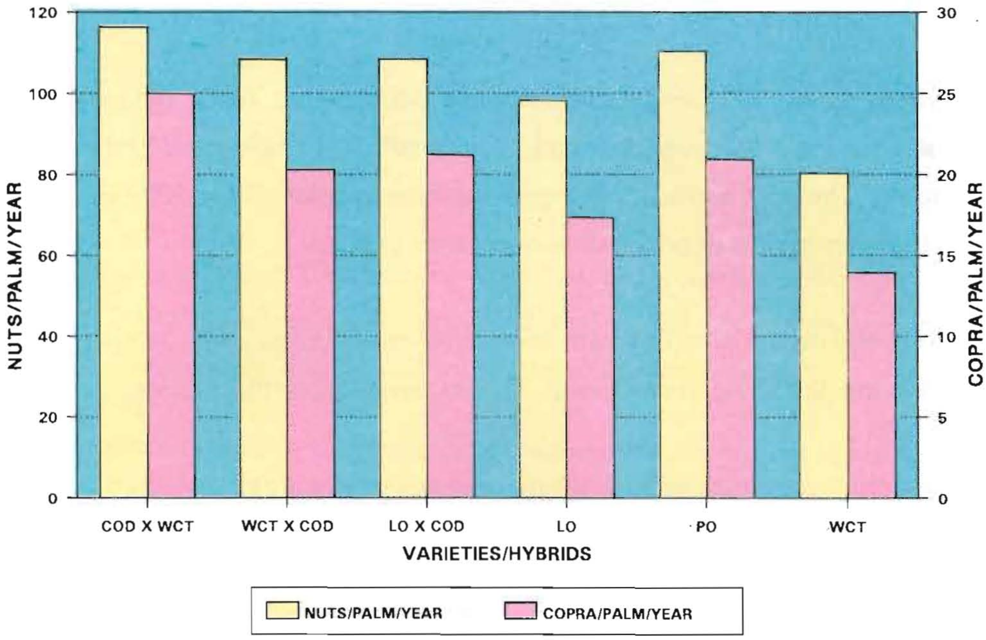
Nutrient indexing of WCT, COD x WCT and WCT x COD palms indicated that hybrid palms do not require higher N, P, K inputs for higher productivity. By evaluating different P carriers, rock phosphate has been found to be a cheap and ideal source for coconut palms. Studies on rationalization of P application to coconut palms indicated that for soil test values of > 20 ppm P, application of P can be skipped.

Application of magnesium @ 500 g MgO per palm is advantageous for root(wilt) diseased palms to restore palm vigour. In arecanut-cocoa mixed cropping system, application of 100:40:140 g N, P_2O_5 and K_2O is adequate for cocoa.

iii) Water management :

For the WCT palms in red sandy loam soils on the west coast, perfo-irrigation with 20 mm water, when pan evaporation totals 20 mm was found to be the best irrigation schedule.

PRODUCTIVITY OF COCONUT VARIETIES/ HYBRIDS RELEASED BY CPCRI



CODxWCT - Chandrasankara

WCTxCOD - Kerasankara

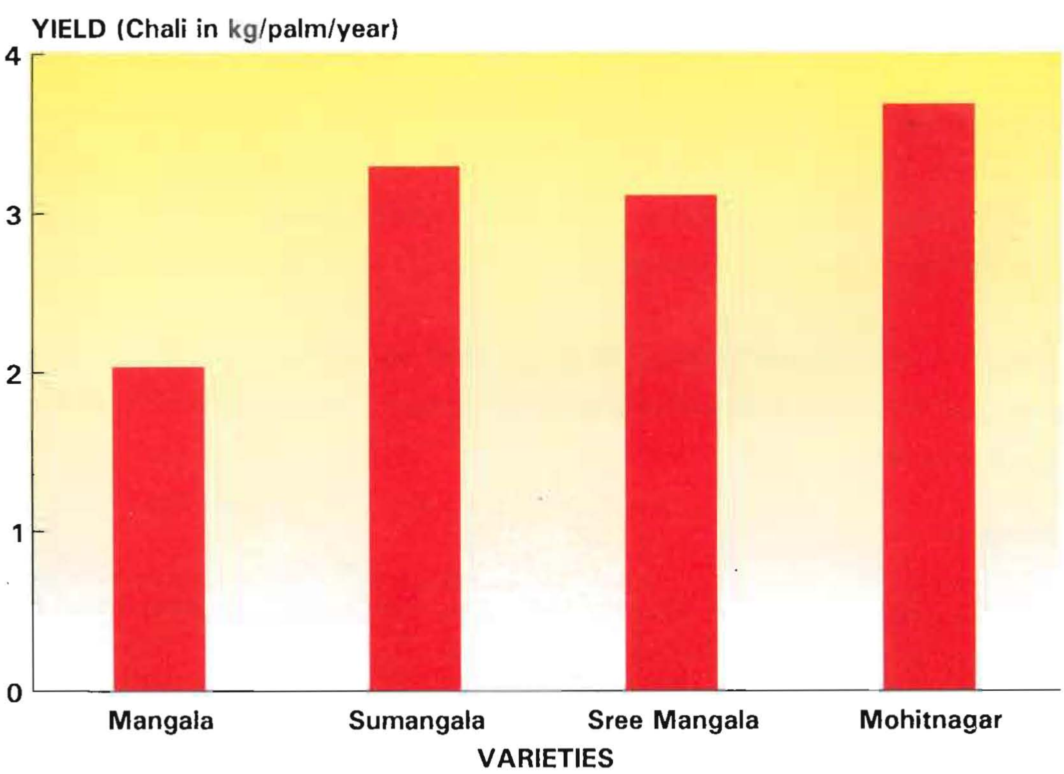
LOxCOD - Chandralaksha

LO - Chandrakalpa

PO - Philippines Ordinary

WCT - West Coast Tall

YIELD OF RELEASED ARECANUT VARIETIES



4.3 Crop Protection

i) Integrated management of diseases :

Coconut root(wilt) disease is contiguously prevalent in eight southern districts of Kerala and in isolated tracts in the northern districts. Research conducted at CPCRI revealed the consistent presence of Phytoplasma in the tissues of diseased palms and their total absence in the disease-free palms. Further support for the mycoplasma etiology was obtained through the successful transmission of the disease using the lace bug vector (*Stephanitis typica*) under insect - proof conditions and through partial remission of symptoms consequent upon the injection of oxytetracycline.

The present strategy developed by CPCRI to combat the disease in the heavily infected contiguous tracts consists of systematic eradication of all palms in the advanced stage of disease and palms infected prior to flowering. Eradication of all the diseased palms is recommended in the northern districts.

Attempts are being made to develop resistant/tolerant lines by identifying disease-free West Coast Tall (WCT) palms in 'hot-spot' areas and utilizing them in the breeding programme with disease tolerant Chowghat Green Dwarf (CGD), as parents to generate hybrids for retesting. F1 hybrids of CGD x WCT have shown field tolerance since last four years in 'hot spots'.

Thanjavur/Ganoderma wilt is widely occurring in Tamil Nadu, Andhra Pradesh and Karnataka. *Ganoderma lucidum* and *G.applanatum* are consistently associated with the disease. Phytosanitation, isolation of the disease affected palms by digging trenches, application of systemic fungicides like Calixin through root feeding, drenching the soil with 1% Bordeaux mixture and application of neem cake @ 5 kg/palm/year are recommended for management of the disease.

Stem bleeding disease is caused by *Thielaviopsis paradoxa*.Chipping the infected bark and application of Calixin followed by coal tar, root feeding with Calixin and application of neem cake @ 5 kg/palm/year are the effective control measures.

Sequential application of fungicides comprising Bordeaux mixture (1%), Dithane M-45 (0.3%) and Fytolan (0.5%) thrice a year after removing and destroying all the severely affected leaves is effective in reducing the leaf-rot disease.

Crown choking disease caused by boron deficiency is an endemic problem in Assam and West Bengal. Application of Borax @ 50-75 g/palm twice a year is effective in controlling the disorder.

Mahali of arecanut caused by *Phytophthora arecae* can be controlled by prophylactic spraying of 1% Bordeaux mixture during the pre-monsoon showers and again after 45 days.

Spear-rot disease of oil palm caused by Phytoplasma is prevalent only in the oil palm plantations in Kerala. Systematic roguing of diseased palms is recommended.

ii) Integrated pest and nematode management :

For the management of rhinoceros beetles attacking coconut, field sanitation, hooking of the beetles from the crown, treating the breeding sites with carbaryl 0.01% and the green muscardine fungus, keeping phorate 10G in perforated pouches in leaf axils, release of baculovirus-inoculated beetles and release of the reduvid predator are recommended.

For the management of coconut leaf eating caterpillar, cutting and burning the severely affected dried leaves/leaflets, spraying of dichlorvos 0.02%, and release of larval, prepupal and pupal parasites are suggested.

Integrated pest management techniques have also been evolved against red palm weevil, root grubs and rodents. Pest control schedules have been evolved against spindle bug and mites attacking arecanut.

Burrowing nematode (*Radopholus similis*) causes lesions and severe rotting of roots of coconut. Studies on the pathogenic effects of the nematode on WCT palms showed that the nematode infestation delayed flowering and fruiting in the affected palms.

4.4 Post Harvest Technology

i) Processing:

Multi-purpose dryers of various capacities using farm waste as fuel have been developed for drying copra, arecanut, cocoa and cardamom.

An electronic copra moisture meter has been designed and calibrated to determine the moisture level in the range of 5 to 40%.

The quality of copra was superior when treated with sulphur dioxide, biogas or neem leaf gas and the treated copra could be stored during rainy season with minimum microbial contamination. The shelf life of coconut oil under high humidity conditions could be improved, by treating with chemicals like citric acid, sodium metabisulphite and common salt.

A pilot plant for extracting edible grade palm oil has been fabricated and erected at Palode centre in collaboration with CSIR. The plant has an installed capacity of 0.75 tonnes FFB/hour. With the commissioning of the mill, the possibility of extending oil palm cultivation to the small farmer holdings in the vicinity of the mill has become a reality. To cater to the needs of oil palm cultivators at the small holders' level, a mini palm oil extraction unit with a capacity to process 200 kg FFB/hour has been developed. The total cost of the unit is around Rs. 3.5 lakhs with an extraction efficiency of 18% of FFB.

ii) Mushroom cultivation on palm waste products :

Freshly fallen areca leaf sheath and oil palm mesocarp waste have been found to be promising substrates for cultivation of oyster mushroom (*Pleurotus sajor-caju*). Oil palm bunch refuse was found to be a good substrate for growing Volvariella volvacea.

4.5 Basic Research / Biotechnology

i) Tissue culture :

A method for non-destructive extraction of tender spindle tissue of mature coconut palms has been developed. Somatic embryoids were obtained by culturing tender seedling leaf tissues. However, protocol for successful tissue culture technique in coconut is yet to be developed.

ii) Embryo culture :

Protocol for aseptic collection of embryos in coconut, their storage and successful culturing to develop plantlets has been standardised.

iii) Tissue culture in oil palm :

Clonal plants were produced from leaf tissues of oil palm seedlings through somatic embryogenesis and field planted. These have flowered and fruited. Adult palm tissues have so far yielded somatic embryos.

iv) Somatic embryogenesis in cocoa :

Direct somatic embryogenesis has been induced from tender cotyledonary segments of cocoa which differentiated into clonal plantlets. Leaf segments from somatic embryo-derived plantlets gave rise to adventive embryos in vitro.

v) Drought tolerance :

Among 40 varieties and hybrids of coconut screened for drought tolerance, six hybrids were found to withstand drought conditions. In cocoa, some Nigerian accessions were identified as drought tolerant.

4.6 Transfer of Technology/Training

i) Training courses:

As a part of transfer of technology programmes, training courses on production technology of plantation crops such as coconut, arecanut, cocoa and oil palm are being arranged every year for the extension personnel of various development departments and research workers.

ii) Operational Research Projects :

With a view to testing the profitability, employment potential and input relationships of the new technologies and studying the socio economic bottlenecks in the transfer of such technologies, two Operational Research Projects on Integrated Land Use Management and Adoption of Package of Practices for the Root(wilt) Affected Gardens were implemented, during 1984-'94. The post-operational survey revealed that there was considerable increase in the nutrient consumption and yield of coconuts and 49% decline in leaf rot disease in root(wilt) affected area.

iii) Lab to land programme

The lab to land programme implemented by this Institute during 1979-88 has helped 1176 farm families to be aware of and adopt improved technologies.

iv) Krishi Vigyan Kendra:

A Krishi Vigyan Kendra was established at Kasaragod during 1993 for effective transfer of technology to the farmers of Kasaragod district and for the upliftment of landless labourers, rural youth, women and schedule castes tribes.

v) Planting material production :

The Institute has been contributing in a modest way in not only supplying quality planting materials to the farmers but also extending technical support and advice for establishing seed gardens in different coconut growing states in the country.

5. IMPACT ASSESSMENT

i) Increased production of coconut

During the seventies and eighties, many high yielding varieties/ hybrids like LO, COD X WCT, WCT X COD and LO X COD etc were released from CPCRI. They are capable of yielding upto 116 nuts/palm/year under rainfed conditions compared to 80 nuts in WCT. Along with the release of high yielding varieties and hybrids, production and distribution of quality seedlings also received greater attention. During 1991, 0.13 million hybrid seedlings were produced in the country and distributed to farmers. Research activities were undertaken in all spheres of coconut cultivation and specific recommendations were made. These research results coupled with vigorous developmental efforts, achieved significant increases in area, production and productivity of coconut in the country. The area under coconut increased from 1.0 million ha in 1980 to 1.69 million ha at present. Similarly the production increased from 5677 million nuts to 13230 million nuts during the same period. The productivity which was hovering around 5249 nuts/ha in the early eighties has increased to 7828 nuts/ha at present. India's position in coconut production in the world has been elevated to first from third (in terms of number of nuts).

ii) Self sufficiency in arecanut

At the time of partition of the country in 1947, India lost 50% of its arecanut area in East Bengal. In the early 1950s, India produced about 60,000 tonnes of arecanut annually which met only half the requirement of the country. The deficit was being met by imports from several South-East Asian countries. To bridge the supply-demand gap, R & D efforts were intensified. Technologies were developed for seed selection and raising seedlings. Manuring and irrigation schedules were worked out for various agroclimatic regions of the country. These went a long way in raising the area under arecanut and in upgrading the existing gardens. This was followed by appropriate recommendations for controlling the major pests and diseases. By early 70s, the Institute released Mangala and subsequently three more high yielding varieties viz., Sumangala, Sreemangala and Mohitnagar were released. The adoption of recommended package of practices coupled with the tariff protection by the Government of India helped to increase production to 140,000 tonnes by 1975 which enabled the country to attain self-sufficiency in arecanut. Further increase in production has been achieved and as on 1994-95, country produced about 0.27 million tonnes of arecanut from an area of 0.23 million ha, the average yield being 1157 kg/ha.

iii) Indigenous production of cocoa

One of the most notable achievements of the multiple cropping trials carried out at the Institute is the finding that cocoa can be raised successfully as a mixed crop in both arecanut and coconut plantations. Until 1964, cocoa was known in India only as an ornamental plant or grown as a curio in some gardens. India was importing the entire requirements of cocoa beans. By the early 70s cocoa became the most successful and popular mixed crop in arecanut and coconut plantations. Today, about 12,000 ha of garden land has been mix-planted with cocoa in India. The present annual production of cocoa beans is around 6800 tonnes which partly meets the needs of the cocoa based industries.

iv) Initiating research activities on oil palm

The demand for vegetable oil during the past two decades has increased at the rate of five per cent per annum while the supply has increased only at the rate of two per cent. To meet the increasing demand, India has been exploring the possibility of cultivating oil palm, the crop which gives the highest oil yield per hectare. The CPCRI started systematic research programmes on oil palm during 1975 at its Palode Research Centre. By the time the country was primed for large scale oil palm cultivation, the Institute had already established the research backup required for oilpalm production. Establishing a modest gene bank, identifying *dura* and *pisifera* parents and producing about 0.3 million *tenera* hybrids indigenously per annum, developing suitable agrotechniques including fertilizer and drip irrigation schedules, developing suitable plant protection measures against major pests and diseases, introduction of pollinating weevil and developing a commercially viable small scale oil palm mill with the help of RRL, Trivandrum have given great impetus to oil palm cultivation in the country. At present about 14000 ha of oil palm plantations are there in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. To further strengthen the research on the crop, a National Research Centre for Oil Palm has been established at Pedavegi, West Godawari district, Andhra Pradesh.

v) Increasing the economic potential of gardenland holdings

The holding size of majority of the garden lands being small (< 0.2 ha), income from these small holdings is insufficient to keep the holders above the poverty line. However, the production potential of such lands is high because of their favourable location and many other ecological advantages that go with human habitation under homestead setup. Unfortunately, indiscriminate planting of a variety of crops in thick stands has adversely affected the production. Research on scientific farming systems has shown that the income from such small holdings can be increased threefold. Besides, some of these systems offer employment potential as high as 1000 mandays/ha/year as against 150 in monocropping. Adoption of suitable cropping systems after choosing appropriate crops can substantially increase the income generation from small holdings. Many such cropping systems have been developed and demonstrated.

vi) Breeding for resistance against root (wilt) disease

The root (wilt) disease caused by Phytoplasma is a debilitating disease causing an annual loss of around 1968 million nuts (1984 survey). Since no curative control measures are available against Phytoplasma diseases, greater thrust is being given to the development of resistant/tolerant lines. This is planned to be achieved through a two-pronged strategy of screening the available germplasm and identification of disease escapes/tolerant palms in 'hot spot' areas and using them in breeding programmes. This approach has given encouraging results.

The progenies of Chowghat Green Dwarf (CGD) x WCT (tolerant palms identified in 'hot spots') planted in disease endemic areas have not taken up the disease for the last four years.

5.1 Growth (crop/commodity/discipline/area/science)

The area, production and productivity of coconut, arecanut and cocoa during different years are given in Annexure II and their compound growth rates (CGR) are furnished in Annexure III.

i) Coconut:

The area and production of coconut in India had shown a fluctuating trend between 1973-74 and 1982-83. Thereafter both area and production had shown a steady increase. According to the projections of the National Commission on Agriculture(1976), by 2000 AD, the area under coconut would be 1.05 million ha with an annual production of 12000 million nuts. However by 1993-94, the country has surpassed this target both in area and production. The compound growth rate of both area and production were higher (3.97 and 7.43 per cent per annum) between 1983-84 and 1994-95 as compared to 1973-74 and 1982-83 (0.18 and 0.14 per cent). The productivity showed a marginal decline between 1973-74 to 1982-83 (-0.03 per cent), but later showed an increasing compound growth rate of 3.35 per cent.

ii) Arecanut:

The arecanut area has increased at a marginal rate of 0.02 per cent between 1973-74 and 1982-83, but increased at a faster rate of 2.36 per cent between 1983-84 and 1994-95. During the same period the compound growth rates of arecanut production were 2.44 and 2.87 per cent respectively. The National Commission of Agriculture has estimated that the area under arecanut will remain unchanged around 0.176 million ha till 2000 AD. However, the area had increased from 0.176 million ha in 1972-73 to 0.23 million ha during 1994-95, while the production had increased from 0.151 million tonnes to 0.272 million tonnes during the same period. The compound growth rate of productivity which was 2.43 per cent between 1972-73 and 1982-83 had showed a modest increase of 0.56 per cent in later years.

iii) Cocoa:

The area under cocoa has decreased from 22000 ha to 11000 ha (CGR -5.99 per cent) between 1983-84 and 1993-94. However cocoa production has shown a marginal increase from 5000 tonnes to 6700 tonnes (CGR: 1.30 per cent). The productivity had increased from 0.25 t/ha in 1983-84 to 0.60 t/ha in 1993-94 (CGR 7.77 percent).

iv) Exports / Imports:

Coconut and arecanut products find a ready market in India. The present coconut production is just sufficient for internal consumption. To meet the internal demand, import is also resorted to in the form of copra or coconut oil whenever there is shortage of coconut oil. Consumption of coconut and its products move in tune with the growth of population, relative price of other vegetable oils, increase in per capita income and elevation in purchasing power of the poor and middle classes. However in coir industry India tops the world trade earning valuable forex (Annexure IV).

5.2 Input Output Assessment

Research on coconut and arecanut was initiated on a modest scale during the years 1916 and 1957 by the then Madras Department of Agriculture and the Indian Central Arecanut Committee respectively. The Indian Council of Agricultural Research had taken over the research on these crops during 1966. The research efforts were intensified with the establishment of Central Plantation Crops Research Institute with its headquarters at Kasaragod during 1970.

The Institute which has the mandate to carry out research on coconut, arecanut and cocoa at present has a sanctioned strength of 113 scientists, assisted by 166 technical, 112 administrative, 532 supporting and 26 auxiliary staff. To carry out its field experiments and for the production of elite planting materials, it has a land area of 390 ha spread in different centres. The budget of the Institute which was about Rs.4.47 million during 1970-71 had increased to Rs. 59.3 million in 1994-95. Recently the Institute has upgraded its computer facilities by establishing Local Area Network and has created modern communication facilities through installation of E Mail system. It has a well established library and documentation services which provide Selective Dissemination Information on specialized areas of research on a regular basis. The headquarters library has 25094 documents including 9893 books and subscribes to 197 journals covering all aspects of plantation crops research and development.

The high yielding varieties/hybrids of coconut and arecanut released by the Institute and the management practices developed have played a key role in increasing the production and productivity of coconut and arecanut in the country. The Institute has so far released three hybrids of coconut viz., Chandrasankara (COD X WCT), Kerasankara (WCT x COD), Chandralaksha (LO X COD) besides a separate variety viz., COD for tendernut purposes. It has also released four high yielding varieties of arecanut viz., Mangala, Sumangala, Sreemangala and Mohitnagar.

Appropriate agro-techniques have been developed for efficient nutrient and water management practices to improve their efficiency. The Institute has done pioneering research and developed many profitable and compatible coconut and arecanut based farming systems to improve the productivity per unit area of land. In addition, IPM practices have been developed for major pests and diseases of coconut, arecanut and cocoa. These research results, together with vigorous developmental efforts have helped the country to achieve self sufficiency in arecanut production and to become the second largest producer of coconut in the world with the annual production reaching 12355 million nuts.

5.3 Item by item assessment

(Indicating where we have failed and why)

i) Breeding for tolerance to root(wilt) disease:

The root(wilt) disease has a history of more than a century and till the middle of eighties no attention was paid for breeding resistant/tolerant varieties to this disease. This is rather surprising since India was the first country to produce a commercial hybrid in the world in the middle of thirties. Right from the establishment of Central Plantation Crops Research Institute, attempts were made to screen the available germplasm at Kayangulam Centre. However the attempts were not successful since the kayal lands in which the experiments were laid out were taken over for a thermal power plant. Resistance breeding has been started only recently.

ii) Coconut tissue culture:

Research to develop a protocol for coconut tissue culture was started at CPCRI about two decades ago. Coconut is a monocot and the recalcitrant tissues are not amenable to successful culturing. Though initially success was claimed to a limited extent, this claim was not substantiated later. Developing a successful tissue culture technique applying the modern biotechnological methods is the break-through required in this field.

iii) Standardization of input requirements for palm based cropping systems:

Though a number of profitable inter- and mixed crops compatible in coconut and arecanut plantations have been identified by the Institute, the information on water and nutrient requirements under the multiple cropping systems is still lacking. The light utilization pattern as influenced by the palm density, planting geography, varieties of the main and component crops, age and agronomic practices is yet to be worked out. To achieve sustained higher productivity at lower level of inputs and for making meaningful recommendations to the farmers, these information are essential.

iv) Water management for palms:

In view of increasing demand for water for domestic and industrial uses, it is imperative to use the available water resources in the most efficient manner by optimizing irrigation schedule and developing modern irrigation systems. Information on optimum quantity of water required under various irrigation systems, frequency of irrigation and fertigation are lacking at present.

v) Drought management in coconut:

Large areas of coconut in the country are still under rainfed condition. Though the scientists have identified a few drought tolerant varieties, there is a need to develop drought tolerant high yielding varieties and standardize the agro techniques like moisture conservation measures to tackle the drought problem.

vi) Formulation of soil-plant-fertilizer models for palms and palm based cropping systems:

To achieve the objective of reduced inputs, nutrient transformation pathways associated with mono and multispecies cropping systems and the interactions among the nutrient elements needs to be understood. There is also a need to reduce the dependence on inorganic fertilizers and identify the most suitable combination of organic, inorganic and bio-fertilizers for optimizing the yield. Information on the behaviour of applied as well as native forms of nutrients in the yield production process is lacking.

vii) Role of secondary and micro-nutrients in palm productivity:

While fertilizer recommendation is available for the major nutrients, the role of sulphur, magnesium, chlorine, boron and zinc are yet to be clearly understood. Systematic studies are yet to be taken up on the role of these elements in increasing the productivity.

viii) Root(wilt) disease of coconut:

The role of Phytoplasma in the etiology of coconut root (wilt) disease has been established and lace wing bug has been identified as the vector through transmission trials. The role of other putative vectors, particularly *Proutista moesta* is yet to be established. The role of soil borne insects, if any, in the transmission of disease is not yet understood. The most important aspect eluding success is the purification of Phytoplasma associated with root(wilt) disease and its culturing. Large scale screening of coconut seedlings for their tolerance to root(wilt) disease is also linked with this programme. Inter-relationship of root(wilt) disease of coconut, yellow leaf disease of arecanut and spear rot disease of oil palm is yet to be understood.

ix) Leaf rot disease of coconut:

The leaf rot disease is always found in association with the root(wilt) disease and the yield reduction in root(wilt) affected palms has been attributed to the leaf rot. Studies are in progress for more than four decades on the etiology of leaf rot disease and more than a dozen fungi have been isolated. Even now the role of each fungus, either individually or in combination in the incident of the disease is not clearly understood. Studies on the role of toxins, if any, produced by these fungi in the incidence of the disease are yet to be taken up. Effective control measures against the leaf rot are not available.

x) Phytophthora diseases of palms :

Phytophthora is a single group of fungi causing maximum crop loss in coconut, arecanut and cocoa. While prophylactic spraying of Bordeaux mixture is recommended for all the *Phytophthora* diseases, particularly the bud rot of coconut, Mahali of arecanut and cocoa pod rot, intensified research on disease forecasting and search for effective alternate fungicides is needed. The interrelationship of different species of *Phytophthora* infecting component crops in palm based cropping systems needs to be clearly understood.

xi) Yellow leaf disease of arecanut:

Though indications are available that the disease is caused by mycoplasma-like organisms, the Institute has not been able to develop an effective management practice and identify disease tolerant varieties.

xii) Studies on pesticide residues:

Newer systemic fungicides and insecticides are being increasingly used in management of the diseases and pests of coconut, arecanut and cocoa. However information on pesticide translocation and decomposition and the residual toxicity in the different parts particularly in the edible parts are lacking.

xiii) Innovative approaches for pesticides application in palms:

There has been a demand, particularly from the arecanut farmers for an effective sprayer replacing the conventional rocker sprayer to reach the tall arecanut palms. Effective and efficient method of application of systemic fungicides through capsules, jelleys, sponges etc are also lacking at present.

xiv) Biological suppression of red palm weevil:

Red palm weevil is a very devastating pest of coconut and it is very difficult to save the infected palms by conventional plant protection measures. An effective early detection method coupled with biocontrol measures and use of synthetic pheromones are imperative for tackling this pest.

xv) Crop-loss surveys:

Only two systematic surveys on crop loss have been undertaken by the Institute so far, one on root(wilt) disease in 1984-85 and the other on yellow leaf disease of arecanut in five districts of Karnataka during 1990. To understand the extent of crop loss, caused by diseases such as ganoderma wilt, stem bleeding and tatipaka disease of coconut, koleroga of arecanut and pod rot of cocoa, systematic surveys are required instead of depending on snap observations.

xvi) Studies on cost of production:

Reliable cost of production data are required at frequent intervals for making recommendations regarding the incentives to be given to farmers and price support mechanisms for stabilizing commodity prices, particularly in view of the escalation of cost of production. The Institute even now depends on one or two studies conducted almost a decade back and reliable estimates of cost of production are lacking. While it is an established fact that farming systems developed at the Institute have helped in generating additional income, employment potential and efficient use of resources, more work is needed on the economics of these systems.

xvii) Farm machinery and post-harvest technology:

While a hand-operated coconut dehusking machine and an arecanut dehusker are available, the efficiency of these machinery are below expectations. Attempts are being made to develop power operated dehusker for coconut and arecanut. Increasing labour cost calls for designing and fabricating labour saving tools and implements to carry out various field operations such as palm climbing, basin opening, application of fertilizers etc. No success has been achieved in this field till now.

xviii) Timber utilization:

To improve coconut productivity, removal of senile and unproductive palms particularly in the root(wilt) disease affected areas, and replanting has been approved by the Coconut Development Board. Research on coconut timber processing did not receive any attention in the past and only a year back research on the same has been initiated. If a method had been developed, large number of coconut trees available could have been effectively utilized as in the case of Philippines.

5.4 Lessons learnt and suggestions/options for the future

i) The major option available for combating the root (wilt) disease is to identify disease resistant/tolerant varieties through resistant breeding programme and screening the newer germplasm collections for field tolerance. Simultaneously the *inter-se* materials generated from Chowghat Green Dwarf and West Coast Tall which have shown field tolerance are proposed to be used for establishing seed gardens to produce disease tolerant hybrids. The hybrid seedlings generated from this programme can be distributed to the eight disease endemic districts of Kerala in a phased programme for replacing the disease affected palms.

ii) In coconut tissue culture, induction of callus has been a problem and the future will be in using auxins such as IAA, NAA etc since these auxins are most stable and not absorbed completely by anti-oxidants. Further it is also planned to initiate protoplast isolation and regeneration systems. Anther and pollen culture will be also attempted to obtain haploids and isogenic lines in view of the need for inbred lines of coconut. Encapsulation of embryos to get synthetic seeds and possibility of long term storage under low temperature are the programmes envisaged for long term conservation of coconut germplasm.

iii) Attempts will be made to understand the mechanisms for obtaining sustained higher productivity at lower level of inputs in compatible crop combinations. Information on canopy development and rooting pattern will be the additional research programmes contemplated in this regard. Research on computer modeling and simulation of cropping systems will be required to make location specific recommendations and offer package of cafeteria for different agroclimatic conditions.

iv) To provide information on optimum quantity of water required under various irrigation systems, it is proposed to initiate experiments on frequency of application under various systems and also application of fertilizer through irrigation water.

v) Research on soil moisture conservation practices and water harvesting techniques such as micro watersheds, *in situ* water harvesting etc are required for more efficient use of rain water. Studies will have to be initiated to know the specific role of micro nutrients in relation to increased productivity of palms and also to know the interaction of these nutrients.

vi) Attempts will be made to culture the Phytoplasma causing the coconut root(wilt) disease, yellow leaf disease of arecanut and spear rot of oil palm, which will facilitate rapid screening of seedlings for tolerance to these diseases. By cross inoculation and transmission studies, the inter-relationship among these diseases is also proposed to be investigated. The role of soil borne insects in transmitting the root (wilt) disease is also planned to be studied.

vii) The role of individual fungus isolated from the leaf rot affected tissues in the causation of the disease will be investigated. It is also proposed to undertake effective control measures against the leaf rot disease which incidentally contributes towards the crop loss in root (wilt) affected palms.

viii) Sensitive diagnostic techniques for important diseases of palms such as root (wilt), Ganoderma wilt and Tatipaka diseases of coconut and yellow leaf disease and Ganoderma wilt of arecanut are to be developed to detect the disease well before the visual symptoms are apparent. Large scale screening methods using ELISA, DNA probe etc are to be developed.

ix) Earlier experience in crop loss surveys indicated that there is a need for undertaking such surveys for assessing the extent of the disease spread and crop loss in major diseases at regular intervals preferably once in five years.

x) Efficient IPM techniques are to be developed for major pests and diseases. In this context, intensive studies on biocontrol agents such as insects, nematodes, bacteria, virus and botanical pesticides in the case of insect pests will have to be taken up. The possibility of using pheromones in the IPM programme of some pests like red palm weevil, white grub etc will have to be investigated.

xi) A pesticide residue laboratory will have to be established to monitor effectively the residues in final products of palms and cocoa.

xii) In view of the increasing labour wages, the farmers are looking forward to the Institute for labour saving implements and machinery. It is proposed to strive for improvements in already developed implements like hand-operated coconut dehusking machine and arecanut dehusker. In view of the increasing prodution and productivity of coconut and decline in price there is a need to undertake research on various consumer products such as coconut milk, cream, Nata-De-Coco etc.

xiii) Research on coconut timber utilization will have to be intensified to effectively use the large number of coconut stems available from the uprooting and replanting programme being implemented in Kerala and other parts of the country.

xiv) In order to meet the intensified research programmes indicated above, it is necessary to modernize the laboratories and also improve the existing facilities.

xv) To keep up with the advances in agricultural research, particularly in the fields of biotechnology, production physiology and indexing for virus, viroid and Phytoplasma diseases, there is a need to depute the scientists of the Institute for advanced training within the country and outside. To encourage intellectual interaction among the scientists and also to expose them to the particular field of specialization, sufficient provision will have to be made for sabbatical leave, participation in symposia and seminars etc.

xvi) The research programmes envisaged in earlier paragraphs, require the establishment of advanced centres for Phytoplasma diseases of palms, bio-control of pests and pesticide residue laboratory.

6. SCENARIO

Coconut:

India is the largest producer of coconut in the world (in terms of number of nuts) and ranks first in productivity. During 1994-95, the country produced about 13,231 million nuts from 1.69 million ha with an average productivity of 7,808 nuts/ha. Between 1980 and 1995, the area under coconut had increased by 60 per cent. During the same period, the production had increased from 5,677 to 13,231 million nuts (133 %) and the average productivity had increased from 5,249 to 7,808 (48.75 %).

Indonesia, the second largest coconut producer in the world has an area of 3.69 million ha under the crop with an annual production of 13,157 million nuts. The productivity level is comparatively low at about 3,560 nuts/ha. The Philippines, another major producer and exporter of coconut and its products in the world has an area of about 3.10 million ha. The total production was about 11,200 million nuts during 1994, but the average productivity was only 3,660 nuts/ha.

The Indian coconut production scenario is dominated by the four southern states viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh which account for about 90 per cent of the total area and production. Between 1980-81 and 1994-95, the share of Kerala state has declined from 67% to 54% in terms of area and from 54% to 43% in case of production. During the same period, the share of Karnataka has marginally declined from 17% to 16% in the case of area and from 16% to 11% in terms of production. On the other hand, the share of Tamil Nadu has increased from 12% to 16% in terms of area and from 20% to 27% in terms of production. Though the share of Andhra Pradesh in the area under coconut has increased only marginally (from 4% to 5%) the State's share in production has more than trebled (from 3% to 10%). This clearly indicates the potential for coconut development in the east coast. The Coconut Development Board (CDB) has identified nearly 0.69 million ha as potential area for the expansion of coconut cultivation. This includes 0.20 million ha in traditional areas of which about 62 per cent is in the east coast mainly in the states of Tamil Nadu and Andhra Pradesh. The potential for expansion in non traditional areas is about 0.49 million ha of which about 50 per cent is in Madhya Pradesh and the rest in the states of Bihar, West Bengal, Andaman and Nicobar Islands, Maharashtra and the North East. It has been projected that by 2000 AD the area under coconut will be about 2.0 million ha with an expected production of 20,000 million nuts.

Arecanut:

India continues to dominate the world in area, production and productivity of arecanut and the country has already crossed the production target set for 2000 AD. During 1994-95, the country produced 0.27 million tonnes of arecanut from an area of 0.23 million ha and the average productivity was about 1156 kg/ha. The other arecanut producing countries like Myanmar, Malaysia and Indonesia account for about 20 per cent of the global production. In spite of the Government policies which discourage area expansion, attractive prices which prevailed during the past few years was mainly responsible for the annual increase of about two per cent in the area. There is not much scope for international trade in arecanut and most of the production is domestically consumed.

Cocoa:

The international production scenario of cocoa is dominated by countries such as Cote De Ivorie and Brazil which account for 31.5 and 13.5% respectively of the global cocoa production. The contribution of India to the world production is negligible, around 0.27%. During the last decade the area under cocoa cultivation has declined considerably and the present area is only about 12,000 ha with an annual production of 6800 t. By 2010 AD the domestic demand for cocoa is estimated to be 12,000 tonnes and it can be met through the increase in productivity (to 1000 kg/ ha from 566 kg/ha at present).

6.1. Strengths

The area, production and productivity of coconut has shown a steady increase during the last decade. The increased production finds a ready market due to increased demand for raw nuts for culinary purposes and unsatisfied demand for vegetable oils. Large gap existing between the demand and supply of vegetable oils in the country and higher demand for raw nuts as a result of improved standards of living will ensure a ready market for coconut in the coming years.

The availability of high yielding varieties/hybrids suitable for different agroclimatic regions and favourable soil and weather conditions prevailing in different regions, will facilitate expansion of the area under the crop to meet the ever increasing demand. There is an excellent research network under the CPCRI and AICRP on Palms and the establishment of CDB had given a boost to the developmental activities.

The coconut palm has innumerable uses and all the plant parts are economically important. Besides there is tremendous scope for making value added products through product diversification. The coir industry is also slowly regaining its past glory. Release of four high yielding arecanut varieties, coupled with the progressive, innovative and forward looking nature of arecanut planters has helped the country to make rapid strides in areca cultivation and attain self sufficiency. Highly remunerative prices realized during the past few years have further enthused many farmers to take up arecanut cultivation.

Cocoa is grown as an understorey crop in coconut and arecanut plantations. It is a compatible mixed crop, which provides additional returns to the farmers. India still imports cocoa beans to meet its increasing requirements. Thus there is good potential for increasing cocoa production.

6.2 Weaknesses

The presence of a large number of senile and unproductive coconut palms in the absence of a systematic replanting programmes and the unwillingness of cultivators to cut trees yielding even a few nuts is one of the major weaknesses in coconut culture. Nine coconut hybrids have been released for cultivation. But the production of hybrid seedlings is limited due to delay in the establishment of seed gardens with the required parental lines.

Non-availability of resistant/tolerant varieties for major diseases like root(wilt) disease in coconut and yellow leaf disease in arecanut and lack of varieties suitable for higher altitudes and latitudes is another constraint.

Large scale fluctuations in coconut prices and the long time lag in response to improved management practices and the long pre bearing phase dampen the enthusiasm of farmers to adopt the latest agrotechniques.

Arecanut palm is more sensitive to moisture stress than coconut and therefore its cultivation is restricted to areas with well distributed rainfall or assured irrigation facilities. There is not much scope to use the crop for purposes other than as a mastigatory and over production may result in a price crash.

Lack of marketing facilities and fall in domestic prices due to indiscriminate imports has forced many farmers to abandon cocoa cultivation. As the processing sector is concentrated in a few multinational companies, there is scope for price manipulation and cartelisation.

6.3 Threats

Unstable prices of the commodity in the market constitutes a major threat to coconut cultivation. The instability in price is quite evident if one scans the price of coconut and its products for the last one or two decades vis-a-vis the cost of inputs required for coconut cultivation. Labour which is a major input has not only become scarce, but is also becoming very costly. Under the decontrolled price schemes, the cost of chemical fertilizers, especially that of potash which is the most important one for coconut has shot up. As a result the profit realized from coconut cultivation has decreased over the years. Such trends compel the cultivator to neglect his garden resulting in a gradual decline in yield.

A lot of controversy is going on regarding the effect of coconut oil on human health. While one lobby is vehemently arguing against the use of coconut oil on the pretext that continuous use of coconut oil causes heart disease, another group argues that from time immemorial people, especially in Kerala, are using coconut oil without any ill effects. Recently this has been biochemically explained by some scientists in Bombay.

Incidence of diseases like root(wilt) disease of coconut, YLD of arecanut etc. are posing a threat to the cultivation of coconut/arecanut. Since these diseases are caused by Phytoplasma and there is no known curative control measures, the present strategy for the control is only the management of these diseases. Research on the resistant breeding programme especially on coconut root(wilt) has started giving encouraging results.

The ratio of domestic and world prices would indicate the degree of export competitiveness of a commodity. This ratio for edible oils viz groundnut (1.96), soybean (2.29), sunflower (2.32) and coconut oil (2.99) is more than one and so India is in a disadvantageous position. The ratio is the highest for coconut oil among the various agricultural commodities and hence India is in a greater disadvantageous position in the international trade of coconut oil. Liberal imports due to pressure from multilateral agencies like World Trade Organization may lead to depressed domestic prices and consequently lower profits.

6.4 Opportunities

The rapid strides made by the major coconut growing states of Tamil Nadu and Andhra Pradesh in area expansion and productivity improvement during the past decade clearly indicate the potential for expansion of coconut cultivation in the country.

The demand for domestic consumption of coconut can be expected to rise steadily in the coming years with increasing income and population levels. The rate of demand growth of coconut products has outstripped that of supply. Product diversification for the manufacture of value added products like coconut cream, dessicated coconut, nata de coco etc and oleo- chemicals will also ensure a steady market demand and renumerative prices for the higher levels of production anticipated.

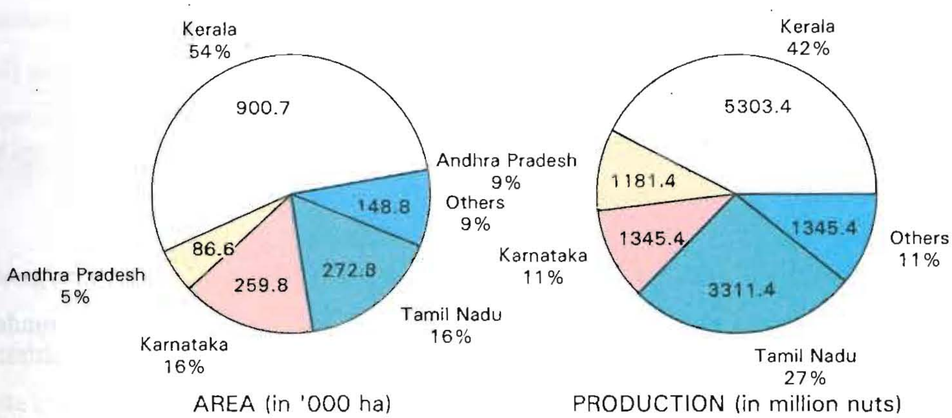
Consumption of tender nuts as a healthy, wholesome drink is increasing day by day. Increased tourist traffic, both domestic and foreign will result in greater demand for tender nuts at more remunerative prices.

Dwindling supply of good quality timber will provide an incentive to coconut farmers to go in for removal of senile palms, if suitable timber processing technology is made available. The Philippines had made rapid strides in this field.

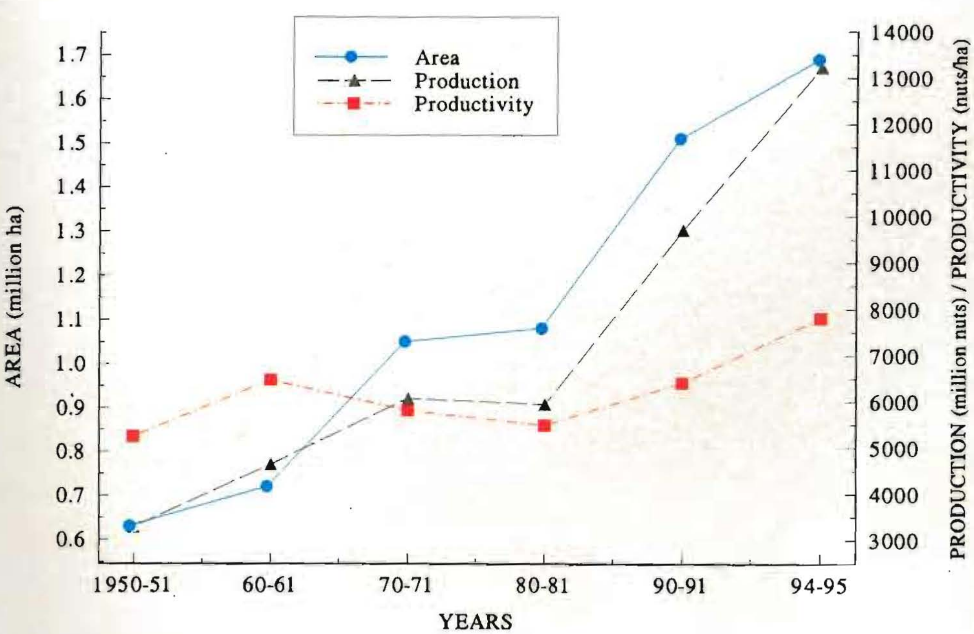
Coir fibre, a byproduct of coconut faced severe competition from synthetics during the seventies and eighties. With change in people's attitude in favour of natural, ecofriendly materials, the industry is slowly regaining its importance.

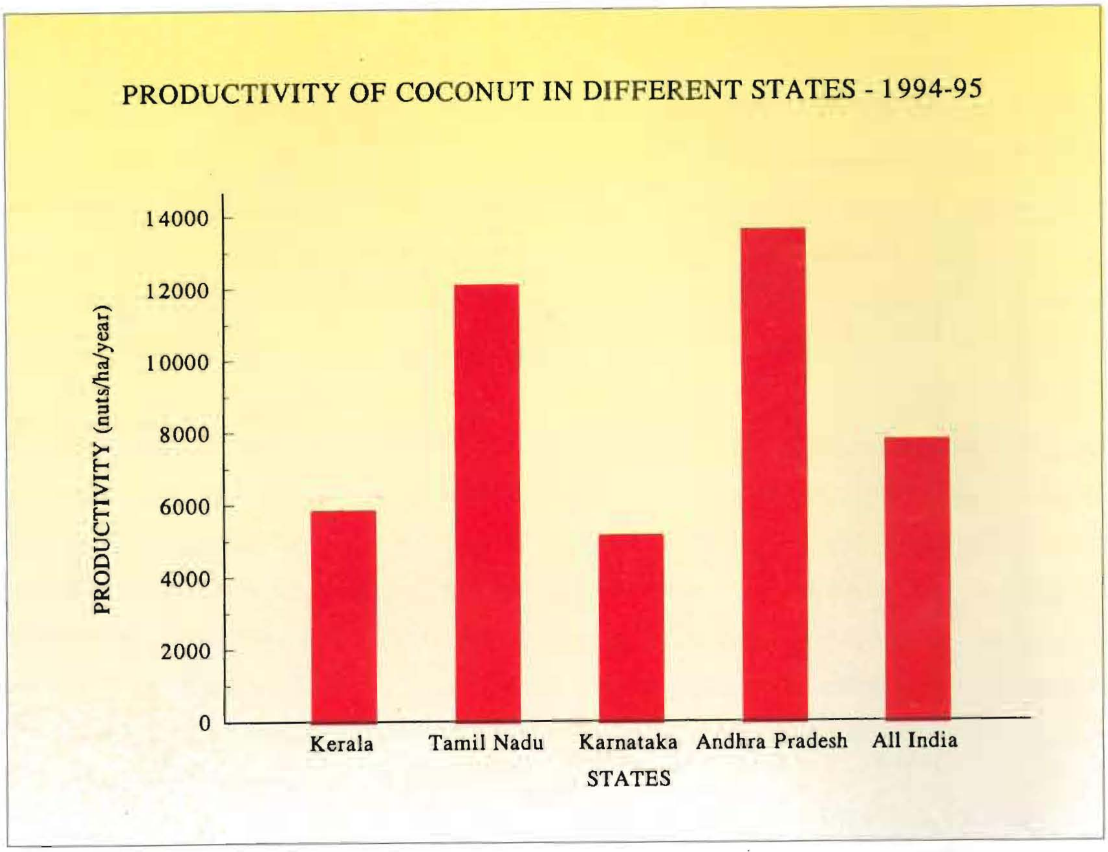
Identification of a dwarf type in arecanut (Hirehalli Dwarf) has opened up the possibility of developing a dwarf high yielding arecanut variety, which is easy for management, especially in harvesting and plant protection operations. Extension of coconut and arecanut cultivation to newer areas under irrigated conditions, offers scope for expanding area under cocoa also.

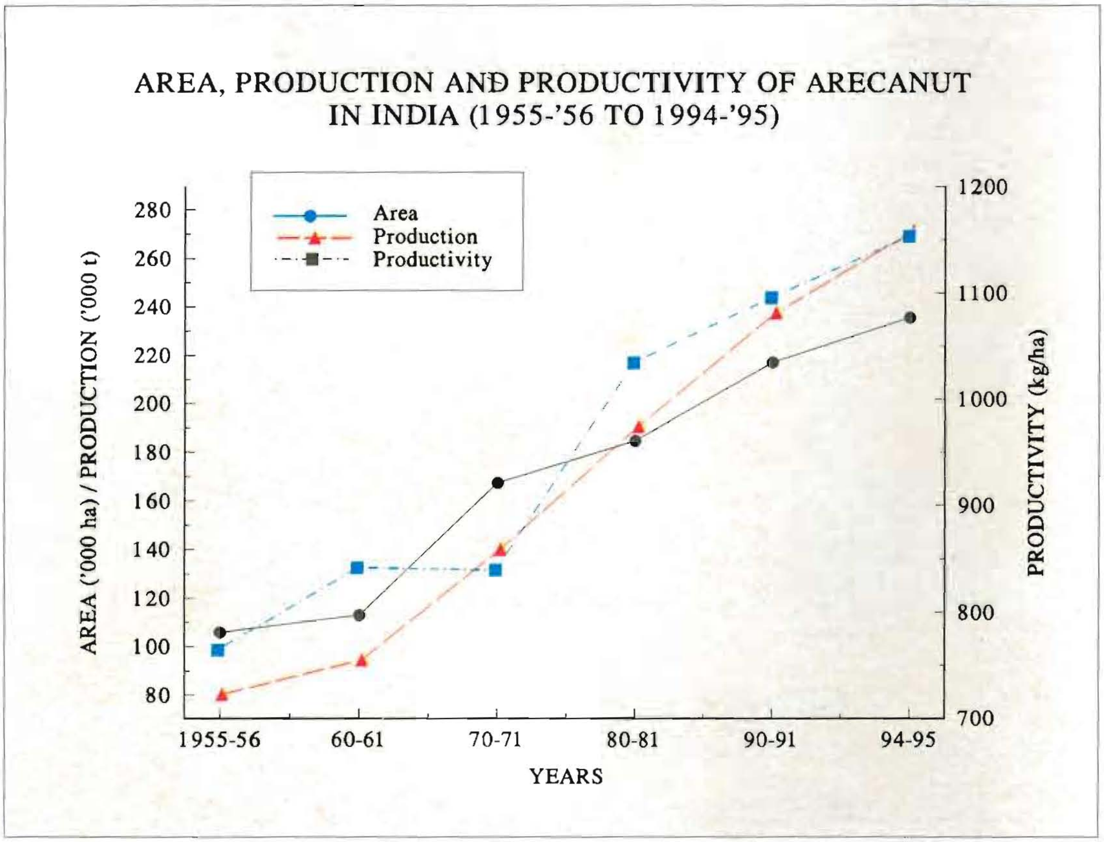
STATE WISE AREA AND PRODUCTION OF COCONUT IN INDIA (1994-95)

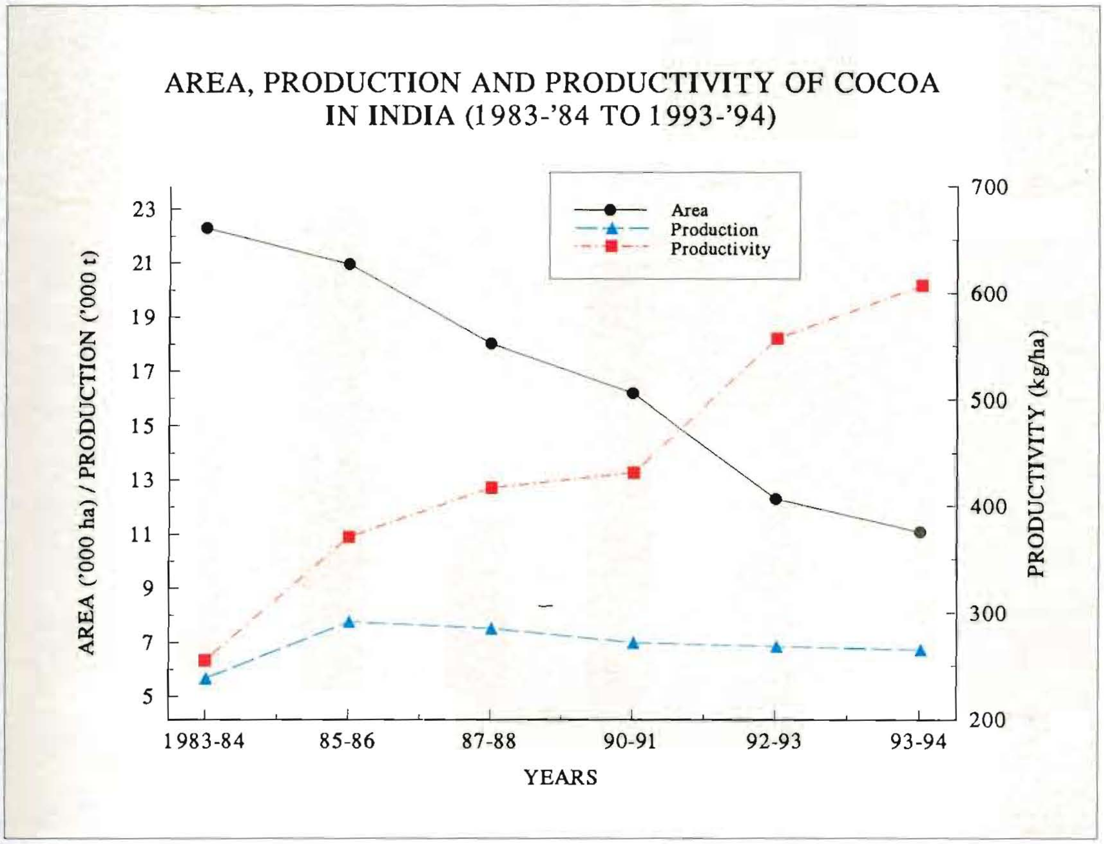


AREA, PRODUCTION AND PRODUCTIVITY OF COCONUT IN INDIA (1950-'51 TO 1994-'95)

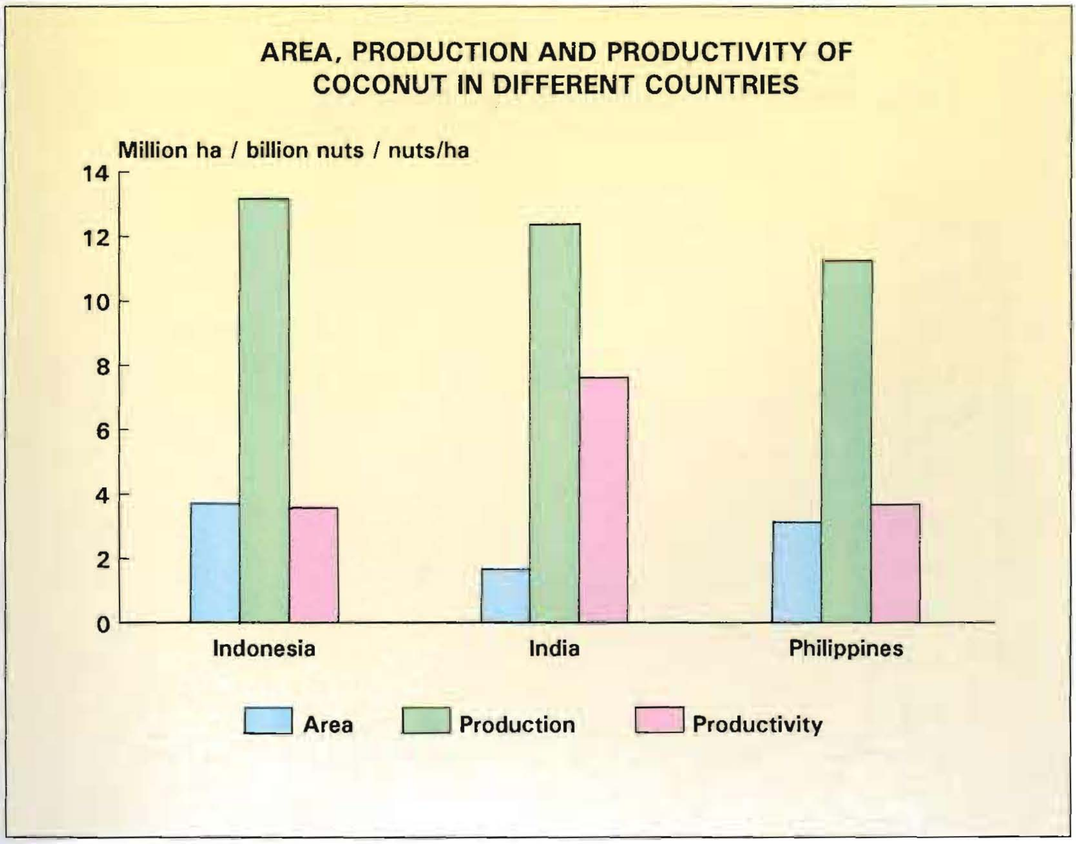



PRODUCTIVITY OF COCONUT IN DIFFERENT STATES - 1994-95
PRODUCTIVITY (nuts/ha/year)
14000
12000
10000
8000
6000
4000
2000
0
Kerala
Tamil Nadu
Karnataka
Andhra Pradesh
All India
STATES


AREA, PRODUCTION AND PRODUCTIVITY OF ARECANUT IN INDIA (1955-'56 TO 1994-'95)
Area
Production
Productivity
AREA ('000 ha) / PRODUCTION ('000 t)
280
260
240
220
200
180
160
140
120
100
80
PRODUCTIVITY (kg/ha)
1200
1100
1000
900
800
700
1955-56
60-61
70-71
80-81
90-91
94-95
YEARS



AREA, PRODUCTION AND PRODUCTIVITY OF COCOA IN INDIA (1983-'84 TO 1993-'94)



AREA, PRODUCTION AND PRODUCTIVITY OF COCONUT IN DIFFERENT COUNTRIES

7. PERSPECTIVE

Coconut is an ecologically desirable crop and plays an important role in the sustainability of the fragile ecosystems in island and coastal communities. In addition, smallholder plantation crops like coconut and arecanut occupy a predominant place in the rural economy. More than 10 million people in rural areas are engaged in the production, processing and marketing of coconut and arecanut. The long term nature of research on these crops, the prospects of higher returns from research investment, and the likely distribution of research benefits to the small holders, make it all the more imperative to develop a long term perspective.

Edible oil is a major component of the diet and demand for fats and oil is increasing faster than the population growth. As per capita income increases, the per capita demand for vegetable oils also increases rapidly from less than 100 calories/day to 200 calories/day. Edible oil production in the country received ι boost after the establishment of Technology Mission on oilseeds in seventh plan. Coconut contributes to about 6% of the total edible oil production in the country but in States like Kerala, it is the most important edible oil among all categories of consumers. Moreover, being a rich source of lauric acid (about 48 %), it is used for the manufacture of a wide range of edible and non-edible products and indispensable in the manufacture of premium cosmetics. This helps coconut oil to retain a market niche and fetch a premium price over other vegetable oils like soybean oil.

Corley (1983) has estimated the potential production of coconut to be 17 t of copra/ha/annum. The best yield reported from a fairly large sized plantation is 6.3 t of copra/ha/annum from a Mawa (PB 121) hybrid plot in Ivory Coast. At CPCRI, Kasaragod, the highest yields realised are around 23700 nuts/ha/annum from the West Coast Tall and about 27300 nuts/ha/annum from the hybrids with assured irrigation. As against this, the average yield in the country is only 7800 nuts/ha/year. The average productivity in Kerala, the largest coconut producing state is still lower (5890 nuts/ha/year). On the other hand, the yield in states like Andhra Pradesh and Tamil Nadu is more than 12,000 nuts/ha/year. This indicates the scope for increasing the productivity by bridging the yield gaps through the use of quality planting materials and adoption of better management practices.

The States of Tamil Nadu, Andhra Pradesh, Orissa and Pondicherry on the East Coast and Assam, Tripura and West Bengal in the North East have made rapid strides in coconut cultivation during the last two decades. These regions have substantially increased their share in the total nut production in the country. There is scope for further expansion of area under coconut in these regions and hence need to develop location specific agro techniques for sustaining and improving the yield levels.

Among the several problems confronting the coconut R & D workers, the root(wilt) disease is the most important one. This disease is caused by Phytoplasma and no control measures are possible. The only lasting solution is to breed resistant/tolerant varieties. The research programme initiated in this regard has given encouraging results and needs to be intensified further.

In most of the coconut growing countries of the world especially in the Pacific and Indian Ocean islands, released varieties/hybrids are slowly replacing the existing populations and the indigenous and exotic germplasm is under threat from genetic erosion. Therefore it is imperative to conserve the germplasm and widen the genetic base for the future breeding programmes. Keeping this in view, expeditions are being planned for germplasm collections from the hitherto under-explored regions.

In recent years there is a steady increase in the area under coconut cultivation. However most of these areas have been planted with non descript local types with very low yield potential. Though a number of high yielding varieties have been released , the country's capacity for the production of these elite planting materials has not kept pace with the demand. Therefore there is an urgent need for strengthening our seed production capabilities not only to meet the requirements for area expansion but also to replace the senile and old palms.

The States of Tamil Nadu, Andhra Pradesh, Orissa and Pondi-cherry on the East Coast and Assam, Tripura and West Bengal in the North East have made rapid strides in coconut cultivation during the last two decades. These regions have substantially increased their share in the total nut production in the country. There is scope for further expansion of area under coconut in these regions and hence need to develop location specific agro techniques for sustaining and improving the yield levels.

Coconut based farming systems are among the oldest farming systems in the world. Cropping systems based on perennials like coconut and arecanut have large biological advantages over other systems as the growing season lasts throughout the year maintain ing a complete leaf canopy for maximising the interception of solar radiation. A number of productive and profitable combinations have already been identified. With the extension of coco-nut cultivation to the newer areas and expansion of area under irrigated conditions, there is greater scope for extending the area under palm based farming systems. The research on agronomic requirements of the component crops in mixed stands with emphasis on the pattern of sharing growth-limiting resources by the component species of the system needs to be intensified. It is also necessary to make recommendations taking into account complimentary and competitive interactions affecting the production of individual species as well as total production of the whole system.

About 5% of the total nut production in the country is used as tender nuts and the rest as matured nuts for various purposes such as household and religious purposes (56%), edible copra (6.5%), milling copra (35.6%), desiccated coconut (1.6%) and seed nuts. Except for copra making and oil milling, there is no major industry on coconut products. Prices of copra and coconut oil in India are much lower compared to the international prices. In the changing scenario, under the WTO regulations and elimination of tariff barriers in international trade, product diversification and value addition is indispensable for the survival of the coconut industry. To meet the increasing demand for processed food items and to compete with countries like the Philippines and Sri Lanka, processing sector of coconut needs to be developed. Hence research efforts on post harvest technology of coconut and its products will be strengthened.

In India, especially in the traditional coconut growing states like Kerala, there are large areas under senile palms which are required to be replanted in a phased manner. With the reduction in the area under forests and shortage of quality timber due to the restrictions on felling forest trees, the utilization of coconut timber will gain more importance. Hence research on timber processing requires priority attention. The timber processing technology, when perfected would help to realise higher prices for the felled trunks which will also act as an incentive to the coconut growers to go for systematic replanting.

India is the largest producer and consumer of arecanut in the world. Till 1971-72, the increase in production of arecanut was mainly due to a rapid increase in area, whereas further increase in production was mainly due to the increase in productivity. At present the average yield of chali (dried arecanut) is about 1.0 kg/palm/year, whereas the potential yield is about 4.0 kg/palm/year. Therefore the research efforts should be directed towards increasing the productivity levels of the existing plantations. In spite of the government policy to discourage the expansion of area under arecanut cultivation, the area is steadily increasing. The end uses of the produce are limited with little scope for product diversification. Hence higher production may lead to a glut resulting in uneconomical price. Under this situation, adoption of arecanut based farming systems, will act as an insurance and research on arecanut based farming sys-tems will be a major thrust area. Arecanut cultivation requires skilled climbers for harvesting and spraying which is becoming scarce and costly. Therefore development of high yielding dwarf varieties utilizing the Hirehalli dwarf as one of the parents will receive priority attention.

Cocoa is a major beverage crop cultivated mainly as an intercrop in arecanut and coconut gardens. The area under cocoa has shown a gradual decline since 1983-'84. However, the productivity had more than doubled and because of the higher productivity, the production of cocoa beans in the country has shown only minor variations. Research should be intensified in the areas of germplasm collection and evaluation, breeding for high yield, better bean quality and resistance to Phytophthora. Standardisation of on-farm processing and marketing will also require greater attention.

Keeping in view the emerging trends all over the world towards the reduced use of chemicals in agriculture for curbing pollution and protecting the environment and to reduce the residual toxicity in the finished products, research will be intensified on the development of IPM techniques for minor pests and diseases as well as integrated nutrient management systems.

8. ISSUES AND STRATEGIES

The ultimate objective of the research programmes of the Institute is to develop technologies for increasing production and productivity of coconut, arecanut and cocoa on a sustainable basis. This could be achieved by developing high yielding varieties/hybrids which are tolerant to biotic and abiotic stresses and making location specific recommendations.

Among the research programmes, developing coconut varieties tolerant to the debilitating root(wilt) disease which is caused by Phytoplasma and for which no curative control measures are available is given top most priority. Enriching the germplasm of coconut, arecanut and cocoa, development of drought tolerant varieties and biotechnology are other priority areas in crop improvement programmes.

Indiscriminate use of chemical fertilizers and inefficient use of water resources add not only to the cost of cultivation, but also result in environmental degradation. Integrated nutrient management including organics and biofertilizers and research on drip irrigation and fertigation will be the thrust areas for achieving higher efficiency of applied inputs and reduction in cost of cultivation. In addition, there is need to develop specific recommendations for the palm based farming systems through systems approach.

The modern trend of research programmes in crop protection is towards reduced use of plant protection chemicals. Hence, development of resistance/tolerant varieties and developing integrated pest management practices including use of bio and botanical pesticides will receive greater attention. There is also need to identify substitute chemicals in the place of those which are banned for agricultural use.

Though the country has made rapid strides in coconut production, technology for making value added products through product diversification and preservation has not received adequate attention till recently. This will be a priority area of research which will help the farmers to earn renumerative prices for their produce, besides helping the country in the export front.

9. PROGRAMMES

The Central Plantation Crops Research Institute has done pioneering work on coconut, arecanut and cocoa production technologies since its inception in 1970. Based on the SWOT analysis, recommendations of the Research Advisory Committee and the Quinqennial Review Team and the emerging trends in the global agricultural scenario, the following major research programmes have been identified for the next quarter century

Crop Improvement

★ Enriching the gene banks
★ Breeding for tolerance to root(wilt) disease and high yield in coconut
★ Development of dwarf arecanut varieties
★ Cocoa breeding for higher yield, better bean quality and resistance to *Phytophthora*
★ Production of elite planting materials

Plant Physiology and Biochemistry

★ Studies on stress tolerance and production potential
★ PAR utilization in Palm Based Cropping Systems
★ Lipid composition of coconut cultivars

Crop Management

★ Studies on palm based farming systems
★ Water management and fertigation
★ Management of drought
★ Development of integrated nutrient management systems
★ Investigations on soil resource constraints
★ Studies on secondary and micronutrients
★ Nutritional management in relation to palm diseases
★ Microbiological and biochemical studies in palm based farming systems
★ Development of biofertilizers

Crop Protection

★ Role of Phytoplasma in root(wilt) disease of coconut
★ Purification and characterization of Phytoplasma associated with palm diseases
★ Sensitive diagnostic techniques for major diseases
★ Studies on leaf rot disease
★ Integrated management of Ganoderma wilt, stem bleeding and *Phytophthora* diseases

- ★ Evaluation of residues of pesticides in coconut, arecanut and cocoa
- ★ Innovative approaches for pesticide applications in palms
- ★ Development of integrated pest management systems for key pests of coconut, arecanut and cocoa
- ★ Bioecology of insect pests and pest surveillance
- ★ Development of botanical pesticides
- ★ Integrated nematode management in coconut, arecanut and cocoa and palm based cropping systems
- ★ Role of VAM in the control of soil borne diseases

Technology

- ★ Developing efficient machinery for dehusking coconut and arecanut
- ★ Development of labour saving machinery/implements for field operations
- ★ Coconut timber utilization
- ★ Product diversification and byproduct utilization

Biotechnology/Basic Sciences

- ★ Plant cell, tissue and anther culture in coconut and oil palm
- ★ Cryopreservation of genetic resources
- ★ Molecular techniques for finger printing and character tagging of germplasm accessions

Social Sciences

- ★ Estimation of crop losses due to key pests and diseases
- ★ Refinement of experimentation techniques
- ★ Software development
- ★ Studies on cost of production of palms ,cocoa and palm based farming systems
- ★ Studies on marketing, consumption pattern and developmental aspects
- ★ Transfer of technology programmes
- ★ Identification of appropriate extension strategies

The justification and rationale for the various programmes enumerated above are discussed in the following pages

CROP IMPROVEMENT

i) Coconut Genetic Resources:

The present number of accessions available with CPCRI is 132. However many of these are represented only by a few individuals. Our future strategy will be to enrich our collections both within the country and also from outside, particularly in the Indian Ocean and African region, South East Asia and some of the Pacific Ocean Islands. In order to conserve the variability existing in the native gene pool, it is proposed to take up surveys for germplasm collection in Andaman & Nicobar Islands, Lakshadweep and North Eastern states, which have not been intensively surveyed so far. Collaboration of agencies like NBPGR and IPGRI will be sought for this endeavour. Now that we have perfected the field collection, storage and retrieval of coconut zygotic embryos (8-11 months old), and applied practically to retrieve some of the Pacific Ocean accessions from WCGC, Andamans to the mainland, scope for enlarging our germplasm collections, has become a reality. An international gene bank will be established at the Kidu Seed Farm in collaboration with the COGENT of IPGRI. Encapsulation of embryos to get synthetic seeds and possibility of cryostorage under ultra-low temperature also indicates the feasibility of establishing a Cryogenic Gene Bank for long-term conservation of coconut germplasm. This could be extended to other palms as well as to the recalcitrant cocoa.

ii) Enriching cocoa germplasm:

The current holding of cocoa germplasm maintained at Vittal and Kannara comprises of 106 exotic accessions mainly of Nigerian origin showing narrow variability for pod and bean characters. Since larger bean size and pleasant aroma commands premium price, we need to augment our germplasm collection especially from the Amazon region, Brazil, Ghana, and North and Central America.

iii) Breeding for high yield and resistance / tolerance to root (wilt) disease in coconut:

Our major thrust in future will continue to be in the area of resistance breeding. Screening for root (wilt) resistance/field tolerance will receive greater attention. The current finding of the field tolerance of the Chowghat Green Dwarf and its hybrids with elite, disease-free WCT identified in the 'hotspots' of south and central Kerala is a happy augury. This will lead to the identification of other green dwarfs of both indigenous and exotic origin, their molecular characterization and gene transfer using both conventional breeding as well as the biotech breeding approaches for the rapid fixation of resistant genotypes and hybrids in a nearly homogeneous, if not homozygous background. These approaches are sure to lead us to a permanent solution to the Phytoplasma diseases and make root (wilt) a thing of the past. This will be a continuous endeavour, since the Phytoplasma is likely to mutate faster than the palm host leading to newer and more virulent strains, which the breeder has to tackle in the years to come. Thus, we have to build up an assembly line of resistant/tolerant types of diverse genetic base to combat the rapidly mutating pathogen. An immunogenetic approach through the identification and use of monoclonal/polyclonal antibodies against the Phytoplasma might perhaps provide a clue to the immunization of the palm from juvenile to adult stages through genetic engineering.

With the discovery of heterosis in hybrids between Talls and Dwarfs in coconut, a number of T x D and D x T hybrids have been released for commercial cultivation and a number of seed gardens have sprung up both in public and private sectors. But the gap between supply and demand for elite planting material is on the increase and hence our capacity for generating parental materials after systematic inbreeding to give inbred lines in Dwarf and Tall parents needs to be strengthened. For this purpose, Kidu Seed Farm requires considerable upgradation into a National Seed Repository of elite parental materials which would form the source of nucleus seed/seedling materials for establishing future seed gardens. A link up with other coconut growing countries in COGENT network will enable us to test the hybrids produced in other countries and select location specific types.

iv) Evolving high yielding dwarf arecanut varieties:

Availability of skilled climbers which is essential for harvesting of nuts and taking up plant protection operations against diseases like mahali in arecanut is becoming costly and scarce day by day. Therefore development of high yielding dwarf arecanut varieties utilizing the Hirehalli dwarf has been identified as a priority item of research.

v) Varietal improvement in cocoa:

Identification of sources of resistance/field tolerance to black pod and canker diseases and evolving hybrids with high yield, disease resistance and better bean quality characteristics is the priority item of work in cocoa breeding.

vi) Production of planting materials:

At present, the annual production of coconut seedlings in the country is about 10 million. However the total requirement has been estimated to be around 15 million seedlings per annum for fresh planting in newer areas, underplanting in the existing gardens to replace senile palms and replanting in root(wilt) affected areas. In order to meet the demand and to ensure supply of good quality planting materials at a fair price to the farmers, it is proposed to convert the Research Centres at Kannara (Kerala), Hirehalli (Karnataka) and Kahikuchi (Assam) as seed gardens. This will strengthen the Institute's capacity to produce DxT, TxD and TxT combinations of superior performance. The Institute will also be supplying the breeder's stock/nuclear planting materials, besides offering consultancy services to developmental departments as well as private agencies for establishment and management of seed gardens. The Institute is also implementing an ad hoc scheme for breeding high yielding root(wilt) disease tolerant coconut hybrids.

At present the demand for seeds/seedlings of high yielding varieties of arecanut is met by the seed farm at Kidu and the Vittal and Mohitnagar centres. With the proposed conversion of Research Centres at Hirehalli and Kahikuchi as seed gardens, the Institute will be geared up to meet the planting material requirements of arecanut.

The demand for planting materials in cocoa is very limited. The seed farm at Kidu is capable of meeting the demand for good quality grafts to the farmers. In addition, efforts are being made to extend the knowledge of soft wood grafting through developmental agencies.

PLANT PHYSIOLOGY AND BIOCHEMISTRY

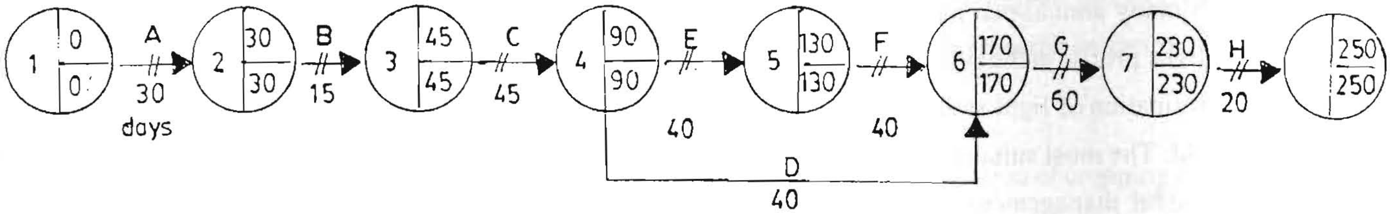
i) Development of stress tolerant varieties/hybrids:

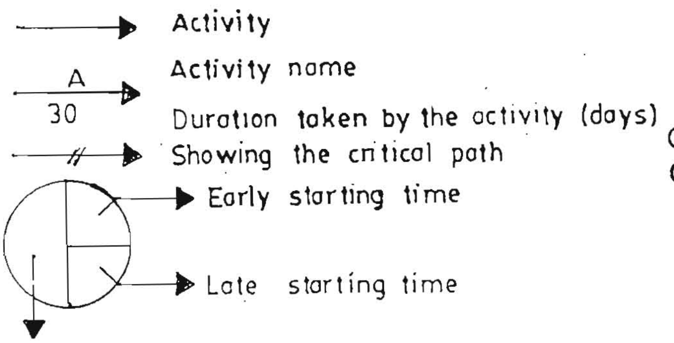
The abiotic (drought) and biotic (diseases/pests) stresses are the major constraints for the ultimate production of crops. Plants develop their own mechanisms of resistance/tolerance to combat stress effects. The identification of factors that impart resistance/tolerance in different genotypes forms the major objective. This can be achieved through in-depth studies on biochemical markers and latest techniques like RFLP, RAPD, DNA probe etc. Large scale multiplication of varieties/hybrids possessing the most desirable traits for stress resistance/tolerance would be the ultimate objective.

ii) Improvement of production potential:

The final yield of crops depends on various factors, of which the genetic potential of the plant itself plays a major role. Although various management practices are adopted, the maximum potential of the crop is seldom

INVESTIGATION ON SCREENING FOR DROUGHT TOLERANCE IN COCONUT





Critical Duration = 250 days

Critical Path :-A- B - C - E - F - G - H

Event No

A. Raising of seedlings

B. Identification and labelling of seedlings

C. Preliminary evaluation

D. Screening of seedlings (Physiological and biochemical parameters) under non-stress

E. Screening of seedlings (Physiological and biochemical parameters) under stress condition

F. Screening of seedling during their recovery phase

G. Compilation of data, its analysis and interpratation

H. Report preparation

realized. In this context, the physiological evaluation of crops for photosynthetic efficiency, water and nutrient use efficiency and dry matter production/partitioning would be an essential area of research that needs to be taken up. Emphasis will be given for identifying the high yielders with good harvest index and to multiply them for large scale distribution.

iii) Palm based cropping systems:

Although many annual/perennial crops are grown under coconut or arecanut, there is lack of complete understanding of light profile in the system and the light use efficiency in relation to energy balance. The long term plan envisages the determination of light saturation in different component crops, photosynthetic efficiency and dry matter production and yield. The most suitable varieties of crops with high yield potential in shaded conditions need to be identified for successful management of cropping systems.

iv) Lipid composition in coconut cultivars:

Coconut oil plays a key role in the economy of Kerala State. There is great awareness about its uses in different sectors, as also health related aspects. The biochemistry of coconut oil has been studied only to a limited extent and there is gap in the knowledge of the fatty acid composition in different cultivars. A systematic approach is required to investigate the percentage of unsaturation. Lipid composition of exotic and indigenous varieties and determination of the ratio of saturated vs unsaturated fatty acids will be a major component of the work. Other areas include isolation of genes coding for the enzymes, DNA sequencing, sequencing of messenger RNA etc.

CROP MANAGEMENT

i) Palm based farming systems:

The production systems under coconut and arecanut range from simple monoculture systems to multiple intercropping systems and farming systems involving field crops, forages and cattle. Small farmers often develop highly complex systems. Multiple cropping in coconut and arecanut plantations is an age old practice, but not often on scientific footing. Based on extensive research conducted over the past several decades, a number of profitable inter/mixed crops and farming system models have been identified to maximize the returns from unit area of plantations, for efficient utilization of resources and for generating gainful employment. Crucial to the success of any farming system involving a multitude of enterprises is a clear understanding of the social, environmental and economic factors involved as well as the choice of crop varieties.

Research on farming systems is a continuous process to identify economically viable and efficient enterprises and to screen newer crops/varieties for their tolerance to shade and amenability for intercropping. It is proposed to identify additional inter/mixed crops including medicinal and aromatic plants and commercial flowers in coconut and arecanut plantations and to workout the management practices for these crops.

Detailed studies on the light profile in coconut/arecanut palm based cropping systems and light utilization pattern as influenced by the palm density, planting geometry, variety, age and agronomic practices are necessary to workout the light availability for under-storey crops, so that best crops could be selected according to their shade tolerance.

Results from ongoing experiments have indicated the scope for reducing the fertilizer input. Further studies on nutrient profile in the soil and crops, soil microbial activity, biomass production and partitioning, nutrient recycling in the systems through various enrichment processes and losses, and micro climatic conditions are essential to understand the mechanisms which have helped the system to achieve sustained higher productivity at a lower level of inputs and for making meaningful recommendations to the farmers. In addition, research on canopy development and rooting pattern is also planned.

It is also proposed to initiate research on computer modeling and simulation of cropping systems with a view to making recommendations for different agroclimatic conditions and offer crop cafeteria for growers, and for making recommendations based on a holistic approach.

It is also envisaged to adopt the Farming Systems Research approach to compliment the traditional research methodologies which will help to understand the socio-economic and ecological factors involved in the adoption of new technologies and help in decision making regarding the recommendations to the farmers and priorities for research.

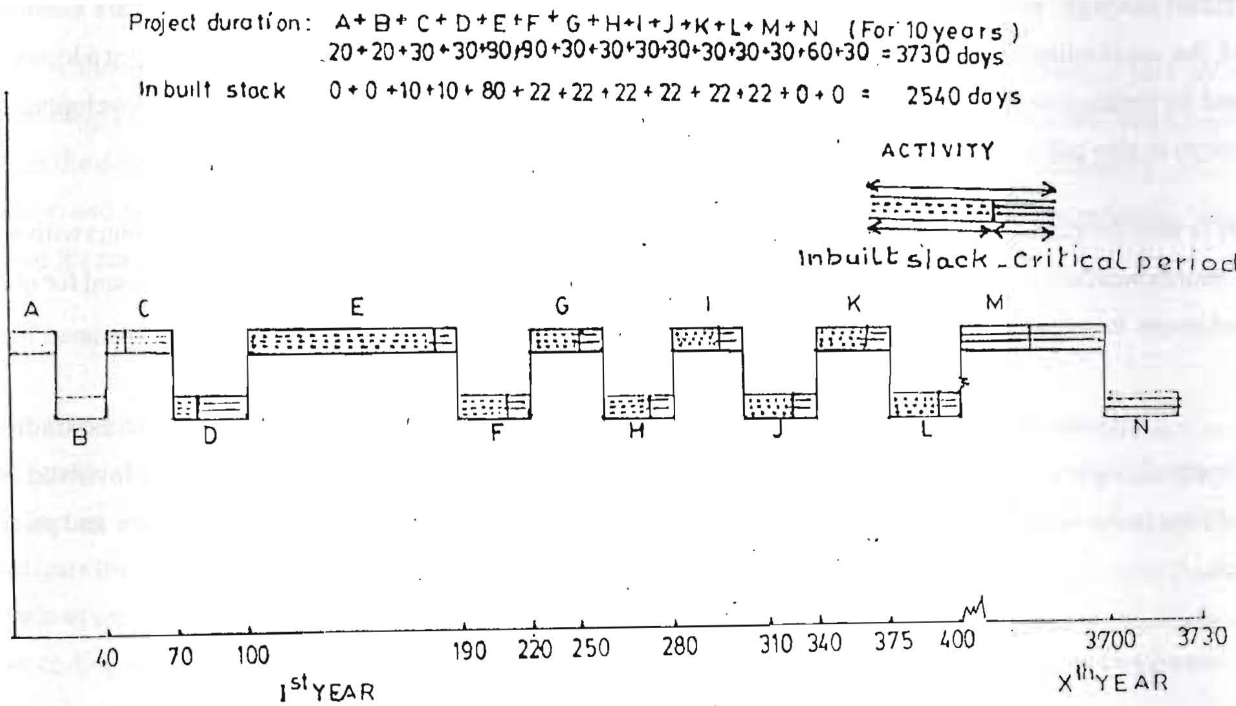
ii) Water management :

Water is one of the most critical resources used in crop production. Though most of the coconut growing areas along the coastal regions are endowed with very high rainfall, it is not well distributed in many areas. As a result, the coconut palms suffer from varying degrees of moisture stress. With increasing demand of water for domestic and industrial uses, the availability of water for crop production is expected to go down in the coming decades. This makes it imperative to use the available water in the most effective manner by optimizing irrigation schedules and developing more efficient irrigation systems for different agro-ecological situations.

Drip irrigation is becoming more popular among the coconut and arecanut farmers owing to the savings in water, energy and labour. Studies are to be continued to determine the optimum quantity of water and frequency of application under different situations. Besides, the minimum quantity and frequency of application to keep the palms surviving under extreme drought conditions needs to be worked out. Application of fertilizers through drip system, known as 'fertigation' will lead to considerable savings in the nutrients and improve fertilizer use efficiency. Research is to be initiated to determine the nutritional requirement under fertigation.

Studies using drainage type lysimeters may be initiated to precisely estimate ET and nutrient losses through leaching. These studies will help to estimate the crop coefficient values, which will be useful in scheduling irrigation.

FERTIGATION STUDIES IN COCONUT



ACTIVITY TABLE

Sl. No.	Activity	Symbol	Preceding activity	Expected duration (days)	Activity work to be started (months after)
1.	Field preparation	A	-	20	-
2.	Lay out of design	B	A	20	-
3.	Soil and leaf sample collection and biometric observation	C	B	20	1
4.	Analysis of sample	D	C	20	2
5.	Installation of drip line	E	D	10	5
6.	Fertiliser application through drip (monthly dose)	F	E	8	6
7.	— do—	G	F	8	7
8.	— do—	H	G	8	8
9.	— do—	I	H	8	9
10.	— do—	K	I	8	10
11.	— do —	L	K	8	11
Activities C to L will be repeated for 10 years					
After 10 years					
12.	Compilation & statistical analysis of data	M	L	60	121
13.	Report writing	N	M	30	123

iii) Drought management:

Even after harnessing all available water resources, large areas of coconut will continue to be under rainfed condition, where droughts are likely to be a recurring feature. To tackle the drought problem, a twin pronged strategy of developing drought tolerant varieties and agrotechniques like soil moisture conservation measures to mitigate the impact of drought are envisaged. For managing drought, research on soil moisture conservation practices and water harvesting techniques such as micro water sheds, *in situ* water harvesting, and water harvesting and recycling for improving water availability for crop production will be taken up.

iv) Development of Integrated Nutrient Management Systems:

Integrated nutrient management in palms and palm based cropping systems is associated with the efficient utilization of chemical fertilizers, production and addition of organic manure, use of biofertilizers etc. To achieve the objective of reducing the fertilizer inputs, the nutrient transformation pathways, associated with the mono and multiple cropping systems, organic farming technologies and yield as a function of nutrient balance are required to be studied in detail.

Refinement of fertilizer prescription models requires understanding of several integrated factors such as fate and behaviour of applied and soil forms of nutrients in yield production processes. A computer simulation model where the nutrient requirement is diagnosed by studying the current soil and plant nutrient status and targeted yield will be developed by collecting a large database incorporating the nutritional variability and its relationship with yield.

The fate of applied nutrients, mechanism of their utilization and efficiency of conversion into economic produce can be better understood by using isotopes. In a perennial crop like coconut such studies are very limited. Investigations involving the use of 14_{C}, 65_{z}, 32_{P}, 35_{S} and 15_{N} are necessary for studying their behaviour in the plant system and when applied to soil.

Luxury consumption of potassium and its associated interactions with other cations has not been studied in palm and palm based systems. Potassium dynamics in soil and associated mineralogy in diverse soil and climatic conditions that support coconut will be studied.

The importance of organic manures in crop production systems is again assuming importance in the current context of sustaining productivity. Leaves, leaf sheath, bunch wastes, coir dust and husks from coconut and arecanut plantations and pods and leaf litter from cocoa plantations are available as sources of organic matter which are hitherto wasted. These highly lignacious materials can be converted into agriculturally acceptable organic manures. The feasibility of using vermiculture technology/composting techniques to convert the waste into useful manure will be studied.

v) Investigations on soil resource constraints:

Management of coconut and arecanut groves and fertilizer applications as an area of decision making needs expertise of the soil factors controlling their behaviour. Earlier studies were limited to mapping the fertility status in certain pockets of the palm growing tracts. This project aims at understanding the soil physical and chemical properties that limit productivity, and devising ways and means to improve them.

vi) Studies on secondary and micronutrients:

In the high rainfall tracts of west coast, deltoic areas of east coast and parts of Assam and West Bengal problems of secondary and micronutrient deficiencies have been reported. S, Mg, Cl, B and Zn are the elements of concern for future in coconut growing tracts on which no systematic studies have been initiated. This project aims at studying the interaction of these nutrients on productivity of palms.

vii) Nutritional management in relation to root(wilt) disease of coconut:

Symptoms like flaccidity, yellowing and foliar necrosis are observed to be associated with root(wilt) affected palms. The project envisages detailed studies on nutritional factors associated with these symptoms. especially those concerning boron, silica, magnesium, potassium and sulphur. In addition, the nutritional requirement of new varieties/ hybrids which will be resistant/tolerant to root(wilt) disease with emphasis on the conjunctive use of organic and inorganic sources needs to be worked out.

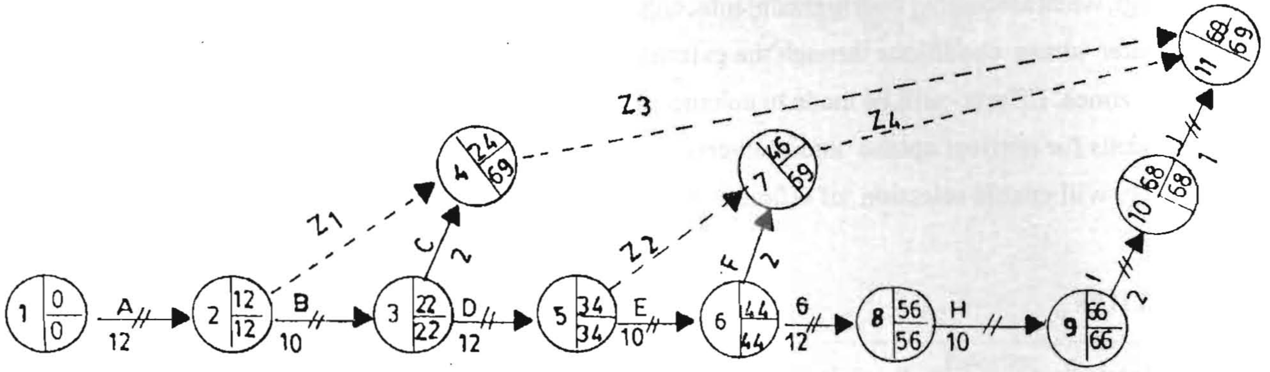
viii) Microbiological and biochemical studies in palms and palm based cropping systems:

Nutrient transformations, i.e. mineralization-immobilization turnover of many nutrients especially those of N, P & S is governed by microbial activities. In the sustenance of palms and palm based cropping systems such microbial activity plays a major role. Information on the role of microbes, population dynamics, the interactive effect of different component crops on microbial population and microbial biomass in such systems is scarce. The project addresses itself in gathering such information which will eventually fit into a functional model explaining nutrient transformation processes. Since coconut is cultivated under different soil types ranging from littoral sands to heavy clay soils, basic studies on microbial ecology under diverse situations will enable to correlate the biological parameters with soil fertility. Studies will also be conducted on endophytic bacteria which are found inside the plant systems and which are capable of supplying biologically fixed N and hormones under field conditions.

ix) Development of biofertilizers:

Biofertilizers and organic manures are vital components in the integrated nutrient management systems for achieving sustainable production. Symbiotic nitrogen fixing potential of cover/green manure legume- *Rhizobium* and tree legume - *Rhizobium* systems could be exploited to reduce the dependence on fertilizer nitrogen in coconut and arecanut palms. Development of biofertilizers based on *Azospirillum* and other associative symbiotic nitrogen fixing bacteria colonizing the roots of palms and cocoa will also receive greater attention as they produce growth hormones in addition to nitrogen fixation.

INVESTIGATIONS ON SOIL RESOURCE CONSTRAINTS OF THE COCONUT GROWING TRACTS IN THE COUNTRY USING FRAME WORKING APPROACH



CRITICAL PATH = A → B → D → E → G → H → I → J

TIME REQUIRED = 69 months

ACTIVITY TABLE

Sl. No.	Activity	Symbol	Preceding activity	Time
1.	Image interpretation and ground truth collection of Kerala, T. N. and Karnataka	A	—	12
2.	Collection and analysis of samples from Kerala T. N. and Karnataka	B	A	10
3.	Constraint analysis for all the three	C	A, B	2
4.	Image interpretation and ground truth collection of Maharastra, A. P. and Orissa	D	B	12
5.	Collection and analysis for samples from Maharastra, A. P. and Orissa	E	D	10
6.	Constraint analysis for Maharastra, A. P. and Orissa	F	D, E	2
7.	Image interpretation and ground truth collection from W. B. and North East region	G	E	12
8.	Collection analysis of samples from W. B. and North East region	H	G	10
9.	Constraint analysis of W.B. and North East region	I	G, H	2
10.	Report writing	J	C, F, I	1

Phosphorus fixation is a problem in acidic soils in which palms and cocoa are grown extensively. Certain groups of bacteria and fungi possess the ability to solubilize the fixed 'P' in soil and make it available to plant roots for absorption. The studies will help in the selection of bacteria which could be used as biofertilizers to enhance the availability of P.

VAM fungi, when associated with higher plants, enhance the absorption of nutrients of low mobility (P,Zn,Cu) and water under water stress conditions through the external hyphae extending from root surface to areas beyond nutrient depletion zones. Efforts will be made to enhance the efficiency of mycorrhizal symbiosis by isolating and testing efficient strains for nutrient uptake under diverse situations. Screening of endophytes under different levels of water availability will enable selection of efficient strains for utilization in drought prone areas.

CROP PROTECTION

i) Role of Phytoplasma in root(wilt) disease of coconut:

Earlier studies have indicated that Phytoplasma are the causative agent of root(wilt) disease of coconut and lace wing bug is the vector. Among the other putative vectors, *Proutista moesta* is a strong candidate. The vector role of this plant hopper through transmission experiment has to be established. The study also envisages conducting critical transmission experiments with putative insects on coconut seedlings to arrive at the number of insects required and acquisition and incubation periods necessary for effective transmission. There is a necessity to assess the role of soil borne insects in the transmission of the disease. Preparation of antiserum for large scale screening of different cultivars of coconut and the insect vectors will be carried out. Since Phytoplasma are not easily culturable, maintenance of Phytoplasma in plant tissues propagated *in vitro* will be attended to. Standardising ELISA for large scale screening of elite palms and nursery seedlings will be taken up. The inter-relationship between root(wilt) disease of coconut, yellow leaf disease of arecanut and spear rot of oil palm will also be studied. Control of the aerial vectors through chemical and biological means and prophylactic and curative measures of diseased palms using chemicals and botanicals will be also be attempted.

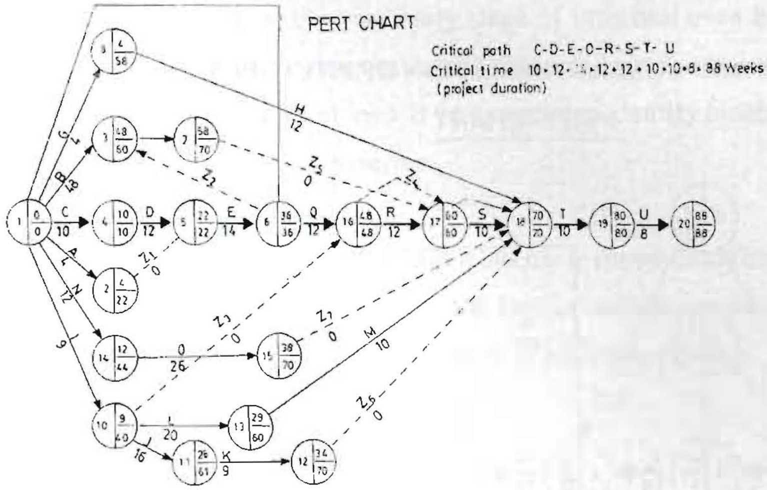
ii) Purification and characterisation of Phytoplasma associated with palm diseases:

Since Phytoplasma are not culturable, their characterisation has been a vexing problem. It is envisaged that the Phytoplasma are fractionated from diseased coconut, arecanut, symptomatic periwinkle, tissues maintained in cultures, insect vectors etc. and characterised morphologically and also ultrastructurally. The chemical constituents of the organism will also be analysed for ascribing the taxonomic position. Production of monoclonal antibodies, screening of plants and insects through ELISA and immunofluorescence, PAGE and Western blotting to characterise Phytoplasma will be taken up. The molecular characterisation of the genomic components of Phytoplasma infecting palms will also be done. DNA probes will be used in detecting Phytoplasma in plants and insect vectors and also developing reliable epidemiological methods and forecasting of disease.

iii) Evolving sensitive diagnostic techniques for important diseases of coconut and arecanut:

It is known that there is a time lag between infection and manifestation of symptoms in the case of root(wilt)

ROLE OF PHYTOPLASMA IN ROOT (WILT) DISEASE OF COCONUT



ACTIVITY TABLE

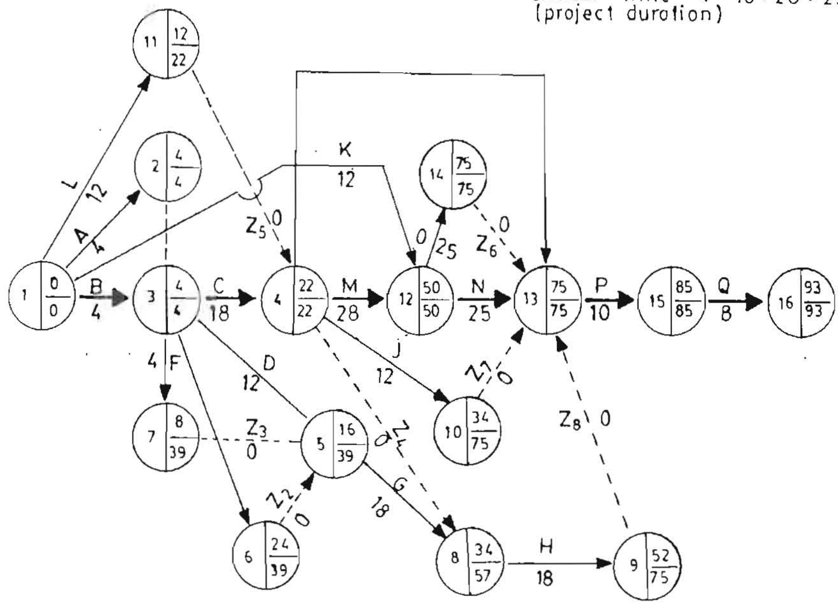
Sl. No.	Activity	Symbol	Preceding activity	Time (Weeks)
1.	Collection of literature	A	--	4
2.	Transmission studies with plant	B	--	48
3.	Construction of insect-proof cages, rearing plant hoppers and rendering them infective	C	--	10
4.	Raising coconut sprouts and inoculation with infective plant hopper	D	C	12
5.	Critical studies with putative insects	E	A,D	14
6.	EM studies to confirm transmission	F	B,E	10
7.	Collection of soil and extraction of soil-borne insects	G	--	4
8.	Study the role of soil-borne insects in transmission of diseases	H	G	12
9.	Identification of diseased palms, collection of specimen and purification of antigen	I	--	9
10.	Preparation of antiserum for large scale screening of different cultivars and insects	J	I	16
11.	ELISA for large scale screening of elite palms and nursery seedlings	K	J	9
12.	Maintenance of Phytoplasma in plant tissues micro propagated *in vitro*	L	I	20
13.	Monitoring the propagation of Phytoplasma through EM studies	M	L	10
14.	Raising coconut, arecanut and oil palm seedlings and transmission of disease through dodder	N	--	12
15.	Assessing the inter relationship between coconut root (wilt), arecanut yellow leaf and oil palm spear rot disease by cross inoculation studies through dodder and insects	O	N	26
16.	Procuring chemicals, botanicals and parasite/parasitoides	P	--	2
17.	Control of aerial vectors through chemicals, botanicals and biological means (filed trial)	Q	P,E	12
18.	Application of prophylactic and curative measures for managing the diseases	R	Q,I	12
19.	Residual toxicity studies	S	Q,R	10
20.	Interpretation of results	T	S,Q F,H K,M	10
21.	Report writing	U	T	8
	Total			270

PURIFICATION AND CHARACTERISATION OF PHYTOPLASMA ASSOCIATED PALM DISEASES

PERT CHART

Critical path = B - C - M - N - P - Q

Critical time 4 + 18 + 28 + 25 + 10 + 8 = 93 weeks (project duration)



ACTIVITY TABLE

Sl. No.	Activity	Symbol	Preceding activity	Time (Weeks)
1.	Collection of literature	A	—	4
2.	Identification of diseased coconut palms and collection of specimen	B	—	4
3.	Purification of phytoplasmas from diseased phylloplane	C	A, B	18
4.	Growing periwinkle and transmission from diseased coconut to periwinkle	D	B	12
5.	Micropropagation of diseased coconut tissues *in vitro*	E	B	20
6.	Collection of lacebugs and rendering	F	B	4
7.	Purification of phytoplasmas from symptomatic periwinkle, plant tissues in culture and infective lace bug	G	D, E, F	18
8.	Morphological and ultra-structural studies	H	C, G	18
9.	Infectivity studies with purified phytoplasmas onto coconut and periwinkle	I	C	40
10.	Protein, lipid and DNA analysis	J	C	12
11.	Organising facilities required for Monoclonal antibody production and purchase of chemicals etc.	K	—	12
12.	Training of scientific personnel on production of Monoclonal antibody work	L	—	12
13.	Monoclonal antibody production against purified phytoplasmas	M	C, K, L	28
14.	Screening of plant and insect samples using monoclonal antibodies	N	M	25
15.	Characterisation through PAGE and Western Blotting	O	M	25
16.	Interpretation of findings	P	O, N, J, I, H	10
17.	Report writing	Q	P	8
	Total			270

disease of coconut, YLD of arecanut, Ganoderma wilt of coconut etc. Hence, it is imperative to develop reliable diagnostic tests which could detect the palms at the very early stage of infection even before visual symptoms are apparent. Among the diagnostic tests used, sero diagnostic test seems to be reliable one. Methods for large scale screening using ELISA, DNA probe etc. can be developed. It is essential to identify biochemical marker which could be used to screen resistant/tolerant seedlings in the nurseries.

In the case of Ganoderma wilt of coconut and arecanut it has been shown that fluorescent antibody technique can be used in early detection of the disease. There is scope for further refinement of this technique to suit to field needs. Similarly diagnostic techniques can be developed against *Phytophthoras* also.

iv) Studies on leaf rot disease:

Studies have shown that in addition to *Bipolaris halodes* (*Exserohilum rostratum*), fungi like *Colletotrichum gloeosporioides, Fusarium* sp., *Gliocladium* sp. etc. are also involved in leaf rot disease. The role of each fungus either individually or in combination in the incidence of the disease and also the etiologic role of these fungi *vis a vis* the changing seasonal factors/cropping may have to be looked into. It is also to be studied whether any of these fungi produce toxin and if so the role of the toxin in the incidence of the disease. The role of other associated agents like mealy bugs and nematodes will also be studied. Effect of suitable systemic fungicides, nematicides, botanicals etc on the pathogen/disease will be investigated. The studies will also enable us to formulate effective and efficient integrated control programmes against disease. The phyllosphere microflora will also be studied with a view to identifying organisms antagonistic to the pathogens. The relation of epicuticular wax in disease incidence will be studied. Screening of coconut cultivars for resistance/tolerance to the disease will also be attempted.

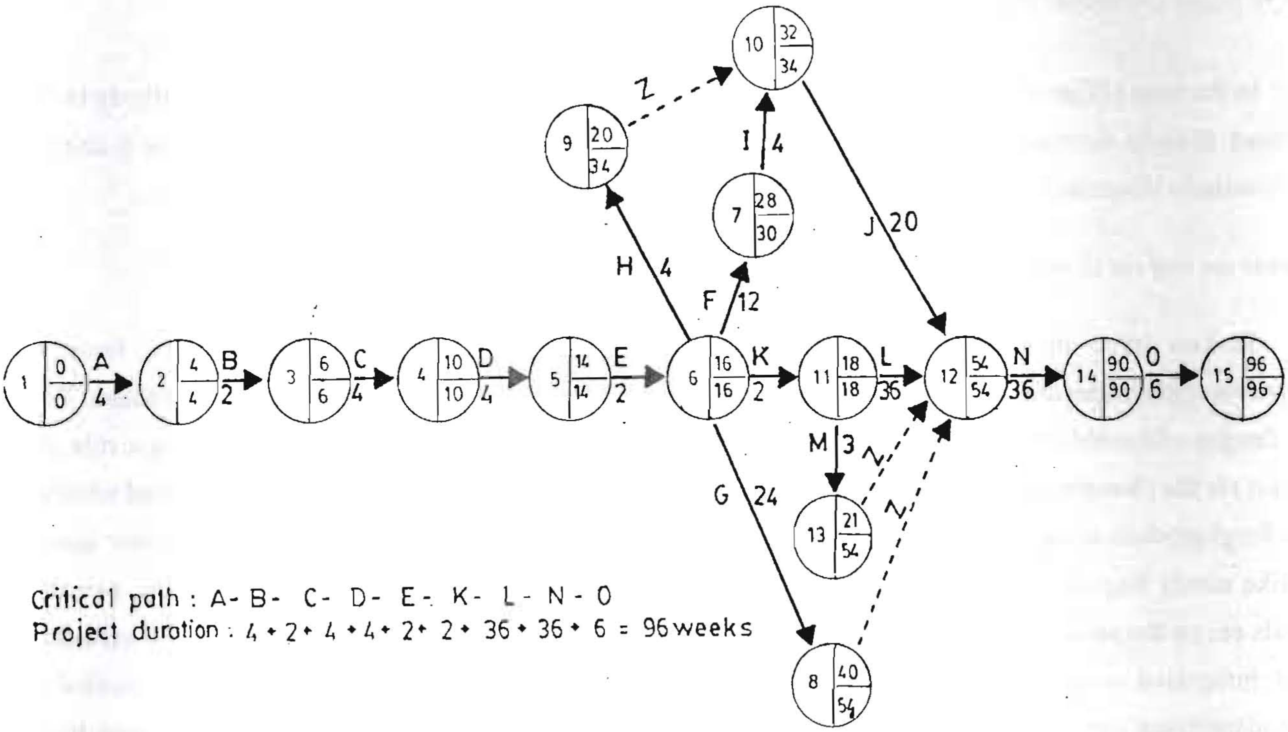
v) Integrated disease management with special reference to Ganoderma wilt and stem bleeding diseases of palms:

In the case of Ganoderma wilt disease of coconut and arecanut it is found that *Ganoderma lucidum*, and *G. applanatum* are involved as causative agents. The biology of the pathogen and the inter-relationship between the isolates of coconut and other palms will be studied. Since this is a soil borne pathogen, the saprophytic ability of the pathogen is also important in the infection and spread of the disease. The spatio-temporal analysis of disease spread will be undertaken. Recent investigations have shown that certain systemic fungicides are effective against Ganoderma and stem bleeding diseases. Attempts will be made to screen newer systemic fungicides to locate more efficient ones. The effect of botanical fungicides on the pathogen/disease will also be taken up. Another aspect of importance will be the use of biocontrol agents. Investigations have enabled identification of certain fungi, bacteria and actinomycetes as efficient biocontrol agents. Efforts will be made to screen more of these biocontrol agents as antagonists. The control measures identified will be integrated for effective management of the above diseases. As a long term measure for the control of these diseases, locating resistance/tolerance is of prime importance. Hence available varieties/cultivars will be screened against the pathogens.

vi) Evolving management practices against Phytophthora diseases of palms and cocoa:

Conventional method of control of bud rot and nut fall diseases of palms and black pod of cocoa is by

LEAF ROT DISEASE AND ITS INTER-RELATIONSHIP WITH COCONUT ROOT (WILT) DISEASE



ACTIVITY TABLE

Sl. No.	Activity		Symbol	Preceding activity	Time (Weeks)
1.	Literature, facilities, disease survey	A	—	—	4
2.	Symptomatological studies	B	A	C	2
3.	Fungal isolations - diseased palms, phylloplane	C	B	D	4
4.	Identification and documentation of fungi	D	C	E	4
5.	Pathogenicity *in vitro*	E	D	F, G	2
6.	Disease reproduction - field palms	F	E	H, I	12
7.	Weather in relation to fungal incidence	G	E	N	24
8.	Growth and interaction of fungi	H	E	J	4
9.	Variability studies	I	F	J	4
10.	Toxin, Host-pathogen interaction	J	I	N	20
11.	*In vitro* screening of fungicides	K	E	L	2
12.	Fungicidal control	L	K	N	36
13.	Screening antagonists, evaluation	M	K	N	3
14.	Integrated management	N	L, M	O	36
15.	Interpretation, report writing	O	N	—	6
	Total				163

prophylactic spraying of 1% Bordeaux mixture during the pre-monsoon season. Because of the difficulty in preparation and application of this fungicide especially during the monsoon season, it is essential that systemic fungicides are screened against the diseases to select efficient ones. The translocation and persistence of the chemicals in the plant system will be studied. Epidemiological studies on the survival of *Phytophthora,* variability etc. will be studied. Studies on the variability of the pathogen using isoenzymes/protein pattern will also be carried out with a view to studying the relationship among the various *Phytophthora* spp. attacking coconut, arecanut and cocoa and also the different inter crops in the system. The mechanism underlying the production of new strains in *Phytophthora* in nature, especially in a mixed cropping system will be studied. The DNA and protein finger printing of *Phytophthora* spp. will have to be carried out to employ them in the early detection. The forecasting of *Phytophthora* diseases of coconut, arecanut and cocoa will be studied under monocrop and mixed cropping systems. Specific and sensitive tests can be developed for detecting and estimating pathogen populations in tissue, debris, soil etc. for detailed epidemiology studies/forecast and also for effecting crop protection. Screening of bacterial, actinomycetal and fungal antagonists as biocontrol agent and screening of germplasm for tolerance/resistance to various *Phytophthora* diseases will be undertaken.

vii) Role of VAM in the control of soil borne diseases:

Prevalence of VA Mycorrhizae has been reported from coconut, arecanut and cocoa. It is well known that these fungi help in nutrient and water absorption, mitigation of drought and also in combating certain soil borne diseases. However, information on these aspects with regard to plantation crops is limited. The project envisages survey, collection, cataloguing and multiplication of VAM and evaluating them against soil borne diseases. The mechanism by which VAM helps in controlling soil borne diseases will also be studied. The study will be useful especially in the case of Ganoderma disease of palms, stem bleeding disease of coconut etc. Studies on the compatibility of VAM with chemicals and biocontrol agents will also be made for effective integration. Methods of multiplying these organisms in mass culture is to be standardized.

viii) Studies on innovative approaches for pesticide application in palms:

Generally for the control of diseases in palms, rocker sprayers are used. It is often experienced that use of such sprayers during monsoon season is difficult especially in tall palms. Hence there is a necessity to devise suitable sprayers for spraying the crown of palms. Standardization has to be done for effective and efficient method of application of systemic fungicides through capsules, gels, sponges etc.

ix) Development of integrated pest management (IPM) system for key pests of palms and cocoa:

This project aims at evolving a feasible IPM schedules for major insect pests of palms and cocoa. Each component under different methods of control will be investigated and the emerging results shall be utilized in the IPM schedule. The programme involves screening of new pesticide formulations, studies on insecticide residues, studies on the genetical methods of pest control, effect of juvenile hormone on the reproductive biology, investigations on pheromones, identifying efficient botanical pesticides, biocontrol and suitable integration of the efficient methods with biocontrol agents.

A good deal of work has been done on the biocontrol of major coconut pests. Fair success was achieved in the control of rhinoceros beetle of coconut with the release of baculovirus under island conditions. Large scale field testing of re-release of baculovirus of *Oryctes* under different agroclimatic regions is to be taken up. Promising parasitoids of *Opisina arenosella* in different agroclimatic regions will also be tested in large scale field trails. Promising biocontrol agents for red palm weevil and white grub pests will have to be evaluated. Genetic improvement of the important bio agents like pathogens and parasites is to be taken up.

x) Bioecology of insect pest and pest survillance:

The objectives of the project are to investigate the impact of changing ecological conditions and crop management on the bioecology of insect pests on coconut palm. Periodic survey on the occurrence of major pests in different agro-climate zones and identifications of pest complex will be taken up. It is also envisaged that the emerging pest problems are identified and economic threshold and injury levels for major pests worked out. Development of suitable techniques to forecast pest outbreak is also envisaged under this programme.

No study has been conducted on the flight range of the vectors of root(wilt) disease. Therefore, attempts will be made to develop radio labeling methods to investigate the flight range of vectors. The project will also undertake work on the strainal variations on different populations of insect vectors and disease incidence. Studies on the screening of coconut cultivars for insect resistance/tolerance will also be investigated under this programme.

The lace bug has been proved as a vector of root(wilt) disease of coconut. In nature this insect is attacked by several natural enemies. As a component of integrated pest management, studies will be conducted to identify the promising natural enemies. After identification, their biology, alternate hosts, feeding potential, mass rearing methods etc. will be studied. Besides lace bug, studies on some more putative vectors of RWD and YLD like *P. moesta* are in progress. Information on the biocontrol agents of such vectors would also be collected. The results obtained from these studies will be utilized in formulating IPM strategies against important vectors.

Cocoa is attacked by a host of insect pests and rodents. Among them mealy bugs, tea mosquito, and several lepidopteran pests are considered as important. For a thorough understanding of these pests, it is necessary to study the biology of these pests in relation to weather, host range etc. It is envisaged to study the seasonal abundance, population dynamics, extent of damage, host range and biocontrol agents of the important pests. There is a symbiotic relationship between mealy bugs and some species of ants. To formulate an effective control strategy, it is imperative to understand the interactions between mealy bugs and symbiont ants. Therefore, investigations will be carried out on mealy bugs of cocoa. The biocontrol of mealy bugs, tea mosquito and stem borer will also receive attention.

xi) Evaluation of pesticide residues:

As is the case with most of the horticultural crops, the use of chemicals, especially systemic fungicides, insecticides and nematicides, results in the pesticide residue problems. Instances are reported wherein certain systemic insecticides and fungicides are administered through the roots of the bearing palms to control pests and diseases. If the tendernut water and meat are consumed from such treated trees, it may lead to health problems.

Therefore, it is necessary to generate data on the persistence of the pesticides and their residues in the edible parts, so as to recommend safe waiting period for each chemical. The residue study will be extended to systemic fungicides/ pesticides and nematicides in other palms and cocoa.

xii) Development of botanical pesticides:

In recent years, studies conducted in several crops proved the utility of botanical pesticides in controlling major pests without environmental pollution. But very little data are available on the control of pests of palms and cocoa. Therefore, wherever feasible, candidate botanicals as well as registered botanical pesticides will be screened to identify the promising ones. Purification, characterization of the active principle, their properties etc will also be studied.

The chemical and mechanical methods at present recommended for the control of major pests of palms and cocoa are outdated. Several chemicals are either restricted or banned for use against plantation crops. In view of this, there is an urgent need to screen and identify newer insecticides approved by the Pesticide Registration Committee against major pests. Hence, bioassay studies with newer pesticides will be conducted against economically important pests. Large scale field trials are also planned to test the efficacy of these chemicals.

xiii) Integrated nematode management in coconut, arecanut and cocoa and palm based farming systems:

Root-knot and burrowing nematodes are known to cause considerable damage and economic loss to plantation crops. The populations of burrowing nematode, *Radopholus similis* isolated from coconut, arecanut, banana and black pepper were identified as the 'Banana race'. Preliminary studies conducted at CPCRI have shown that *R. similis* isolates from the above crops in Kerala have a haploid number of chromosomes. However, the identification of physiologic races of the burrowing nematode affecting different plantation crops by studying the isozyme pattern is yet to be taken up.

In view of the prohibitive cost, inaccessibility, environmental pollution and the likelihood of residual toxicity, use of nematicides need to be minimized. Preliminary studies on these aspects has already been initiated at CPCRI and the studies are to be continued. It is also envisaged that the effect of various organic amendments on nematode control, role of biocontrol agents like nematophagous fungi, bacteria etc on the population of nematodes, use of different botanicals in controlling nematodes and effect of VAM in imparting tolerance to nematode-infested plantation crops, are to be studied. Developing an integrated nematode management schedule with greater emphasis on use of tolerant/resistant varieties and biological control methods is essential.

In India no intensive survey has been done on the association of plant parasitic nematodes in relation to cocoa. Besides the root-knot nematode, *Meloidogyne incognita*, a number of genera of plant parasitic nematodes have been recorded from the root zone of cocoa. Detailed studies on their bioecology, damage and control are to be taken up.

xi) Designing electronic devices for detection and extraction of shoot borers in plantation crops:

The plantation crops are severely attacked by shoot borers which remain inside the trunk during their development and escape detection. By the time external symptoms appear, most of the damage might have already been done and recovery of such plants with the available pesticide treatment is difficult. Hence, the paramount task in the control of tissue borers/ shoot borers is the early detection of the pest. This will help in adoption of the recommended control method at the earliest. So far the success with the prototype device developed for detecting the red palm weevil is limited. It is proposed to design newer electronic devices by removing the short comings found in the earlier prototypes.

TECHNOLOGY

i) Post harvest technology:

There is an urgent need to develop efficient machinery for dehusking coconut and arecanut, which are preferably power operated and have a higher output. It is also essential to improve the efficiency of small scale oil mills to increase the oil yield and reduce the power consumption.

ii) Farm machinery:

Shortage of labour both skilled and unskilled as well as the ever increasing labour costs, necessitate development of labour saving implements/machinery to carry out various field operations like climbing, nursery weeding, opening basins for the application of organics/ fertilizers etc. In addition, development of special equipments like sprayers which can be used for application of plant protection chemicals on the crowns which are at great heights from the ground is also a priority item.

iii) Coconut timber utilization:

Large acreage under coconut consists of senile and unproductive palms, which are in need of replantation. When resistant/tolerant varieties for diseases like root(wilt) are available, large number of disease affected plants are likely to be uprooted for replanting. It is proposed to take up research on a priority basis on coconut timber processing, preservation and utilization not only to increase the income of the growers/economics of replanting, but also to reduce the pressure on forests.

iv) Product diversification and byproduct utilization:

The area and production of coconut and arecanut in the country is showing a steady increase. Most of the coconuts produced in the country are used as matured nuts for household and religious purposes, and to produce milling copra. Except for copra making and oil milling and dessicated coconut, there is no major industry on coconut products. Copra and coconut oil prices in the country, are very high compared to the international prices. In the changing economic scenario, product diversification and value addition is indispensable for the survival of the coconut industry. To meet the increasing demand for processed food items and to compete with countries like the Philippines and Sri Lanka, processing sector of coconut needs to be developed and research efforts on post harvest technology of coconut and its products such as *nata de coco*, coconut cream etc. will have to be strengthened.

In coconut and arecanut plantations, large quantity of waste materials such as leaves, petioles, leaf sheath, coir dust etc. are available. Preliminary work has shown that these waste materials can be effectively used for the cultivation of oyster mushroom. Studies are planned to improve the yield of mushroom by enriching the substrates with organic and inorganic amendments and to screen different strains of oyster mushroom to identify efficient strains. Use of spent substrates after growing the mushroom as organic manure will also be studied.

v) Electronics:

Application of electronics in plantation agriculture for purposes like automation of irrigation systems, moisture meters and process control will also receive attention.

BIOTECHNOLOGY/BASIC SCIENCES

i) Plant cell, tissue and anther culture research:

Technologies have been standardized at CPCRI, for the non-destructive sampling of mature palm tissues from the central spindle, both in coconut and oil palm. However only a limited response in terms of callus and somatic embryoids could be obtained. Hence, experiments were set up for the use of elevated levels of CO_2 in controlled chambers to incubate the cultures, in order to enhance the rate of induction, as well as maturation of somatic embryos and prevent their precocious sprouting leading to weak seedlings. Similar experiments have been set up for oil palm and cocoa.

In oil palm, response has been quite encouraging using 'Eeuwens basic' and 'Blaydes' media, supplemented with high levels (25 ppm) of 2, 4 - D and the cytokinin zeatin riboside. Clonal plantlets have differentiated both via somatic embryogenesis as well as meristemoid formation from seedling leaf tissues. In cocoa, both direct somatic embryogenesis, as well as via limited callus induction have been obtained, leading to plantlets from cotyledon segments and nucellar tissues. In our future strategy, we plan to use conjugated auxins such as IAA - aspartate, IAA - alanine etc. for induction of embryogenesis, since these auxins are more stable and not absorbed completely by antioxidants or activated carbon. It is also proposed to standardize protoplast isolation, culture and regeneration system, to be further used in genetic engineering studies for direct incorporation of alien genes. In view of the crying need for inbred lines in a short time, anther/pollen culture will be standardized to obtain haploids and isogenic lines in coconut and cocoa, the latter being self-incompatible. Both short-term as well as long-term storage methods for embryoids/meristemoids will be standardized including production of artificial seeds. The embryo isolation, storage and retrieval for germplasm in coconut, oil palm and cocoa will be used in future expeditions as per FAO guidelines.

ii) Cryopreservation of genetic resources:

Cryopreservation would provide the means to conserve the genetic resources under *in vitro* conditions for longer periods and eliminate the risk of loss of varieties due to biotic and abiotic factors and therefore serves as a supplement to the field gene banks. Research will be taken up on the cryopreservation of coconut to conserve the available gene pool in collaboration with NBPGR.

iii) Finger printing and character tagging of germplasm:

Future strategy will also include the use of molecular techniques for finger printing and character tagging, constructing a random genomic library, identification of RFLP/RAPD markers associated with resistance/tolerance to the dreaded root (wilt) disease of coconut, and identifying RAPD bands for fingerprinting of coconut accessions. This will bring a lot of precision in our characterizations, cataloguing and evaluation of germplasm for their efficient utilization in coconut breeding and genetic improvement both for yield, quality (ratio of saturated vs unsaturated fatty acids in the oil) and disease resistance.

Once the protocol for somatic embryogenesis and viable plant formation in cocoa is perfected, it will be possible to use DNA- based markers for genetic analysis of cocoa clones, and include protein and DNA-markers in the cocoa descriptor. The study can then be extended to use the DNA, RFLP/RAPD markers for characterizing yield, disease/ drought tolerance, and bean quality in the cocoa accessions and hybrid derivatives. Finally, it is proposed to use the DNA profiles and restriction enzymes to clone the genes controlling stress tolerance and quality parameters for use in gene transfer experiments.

SOCIAL SCIENCES

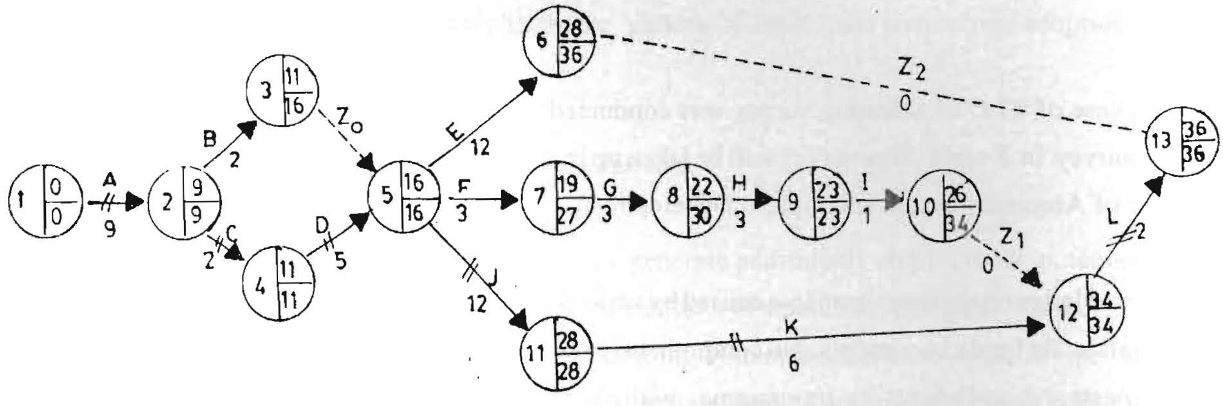
i) Estimation of crop losses due to diseases, pests and nematodes:.

Coconut and arecanut palms are affected by a number of diseases and pests causing considerable loss. In the case of root (wilt) of coconut, survey on the intensity and production loss was done during 1984-85. Since then, the disease has been recorded in some pockets in the Northern districts of Kerala also. No information is available on the further spread of the disease in the Southern Kerala especially in the border districts of Trichur and Trivandrum where the intensity of the disease is mild. Hence, it is envisaged that a comprehensive survey on root(wilt) disease of coconut will be taken up in Kerala.

In the case of Thanjavur wilt disease of coconut, a survey was done in Tamil Nadu by the Tamil Nadu Agricultural University during 1980's. The disease has spread since then to newer areas. No such survey was conducted in Karnataka, Andhra Pradesh and Kerala where the disease occurs. Hence, survey on the disease incidence and loss is to be conducted in the southern states in collaboration with the SAUs, the concerned Agricultural/ Horticultural Departments and Coconut Development Board.

In the case of other diseases of palms and cocoa, no systematic survey has been taken up so far. To understand the incidence and the loss caused by various diseases like bud rot and stem bleeding disease of coconut, Koleroga of arecanut, pod rot of cocoa etc, we are still depending upon the data available from snap observations made in individual gardens. Hence, survey for the incidence of these diseases also should receive priority in the future programmes.

DEVELOPMENT OF MOLECULAR MARKERS TO FINGER PRINT COCONUT ACCESSIONS



ACTIVITY TABLE

Sl. No.	Activity	Symbol	Preceding activity	Time
1.	Purchase and installation of equipments	A	-	9
2.	Standardisation of DNA extraction protocol	B	A	2
3.	Collection and preservation of leaf material from different coconut accession	C	A	2
4.	DNA extraction, purification and quantification from coconut accessions	D	B,C	5
5.	PCR amplification of plant DNA with random prioness and visualization	E	D	12
6.	Genomic DNA library construction and screening of genomic clones	F	D	3
7.	Colony hybridisation and selection of low and medium copy clones	G	F	3
7.	Plasmid DNA isolation from recombinant clones, cross homology check of insect	H	G	3
8.	Large scale plasmid DNA isolation from selected clones	I	H	1
9.	Restriction digestion and blotting	J	D	12
10.	Hybridisation	K	I, J	6
11.	Data analysis	L	E, K	2

To assess the distribution of root(wilt) disease on coconut in different districts of Kerala and in the districts of neighboring states bordering Kerala, infra-red aerial photography can be used. Collaboration with National Remote Sensing Agency, Hyderabad for getting satellite pictures of the area to be surveyed will have to be sought. Infra-red aerial photography can also be used for assessing the YLD incidence in arecanut, Ganoderma wilt disease of palms etc.

In the case of YLD of arecanut, survey was conducted during 1970s and hence there is an urgent need for conducting the survey in Kerala. The survey will be taken up in collaboration with Agricultural Department of Kerala and Directorate of Arecanut, Cocoa and Spices Development.

Our knowledge on the exact crop loss caused by various pests and nematode of coconut, arecanut and cocoa are mostly from small scale field experiments. No comprehensive survey has been taken up to assess the crop loss caused by important pests. A collaborative programme with the help of Departments of Agriculture/ Horticulture, Agricultural Universities and Developmental Agencies is envisaged to achieve the objective.

ii) Refinement of experimentation techniques:

Because of the perennial nature of the crops, experiments on palms are continued for several years. Besides, due to the large error variance and differential response of individual palms, even large treatment differences fail to show statistical significance. The data available from many concluded experiments will be critically examined to develop techniques/methodologies for reducing the error variance in field experiments so that treatment differences can be detected. Suitable statistical procedure for palm based cropping/farming systems research is another area which requires urgent attention.

iii) Software development:

Information systems and computers will play an ever increasing role in all facets of human life in the twenty first century. At present, computer software is available for many annual crops and some horticultural crops to predict plant growth and make recommendations to farmers. Data bases will be created on crop characteristics and requirements, soil properties and environmental conditions from the data collected in the experimental palms of the Institute and AICRP on Palms as well as published literature. Based on the data bases, software will be developed for making recommendations to planters. Statistical techniques will also be developed to assess the 'genetic improvement' in breeding programmes and evaluate breeding strategies in terms of 'effective population size' and possible inbreeding depression.

iv) Cost of production:

Estimation of farm income as a whole and cost of production is the basis for devising measures for the provision of incentives to the farmers and to stabilize agricultural prices. Results of farm cost studies also provide practical recommendations for improving the efficiency of production and are consequently of great value to extension workers. Unlike in the case of annuals, the estimation of cost of production of perennials are not straight forward because of long economic life span. Besides, once investments are made and resources are committed, reversion is not easy. Studies on cost of production of coconut will be taken up in the four major producing states of the country viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. A similar study will be undertaken for arecanut in Kerala and Karnataka. The study will also highlight the pattern of input use, technology adoption and constraints in adopting them at field level.

v) Economics of coconut and arecanut based farming systems:

Perennial crop based farming systems help to generate additional employment potential, improve the resource use efficiency and provide higher net income to millions of small and marginal farmers. The technical feasibility and economic viability of various cropping/farming system models developed at the Institute and the constraints faced during adoption will be evaluated in different states under varying agro-climatic and socio-economic situations.

vi) Studies on consumption pattern and developmental aspects of plantation crops and product diversification :

Copra which is the major product from the coconut palms is widely used as a source of vegetable oil for edible and toiletry purposes. Now a days, the consumption pattern of vegetable oils as a cooking medium is undergoing fast changes and other vegetable oils are slowly gaining importance, particularly in urban markets. On the other hand, the area under coconut and its production in the country shows an increasing trend. Micro level studies on the consumption pattern of coconut and its products by consumers of different strata both in rural and urban areas, will be taken up with a view to identifying the overall demand and supply of coconut, copra and coconut oil and to project the future demands. Apart from copra, coconut has a wide range of products such as nut water, coconut cream, dessicated coconut, activated charcoal, coir etc. Except for the coir industry, others are in their infancy in India. However, product diversification is indispensable for maintaining the competitiveness of coconut industry and profitability of coconut culture. Consumer awareness, market demand and supply of coconut products and economics of their production will be studied and policy measures for their further prospects and expansion to newer areas will be suggested.

vii) Marketing:

Marketing is another area which requires greater attention. Studies on different aspects of marketing viz., role of different agencies involved in the marketing of the mandate crops, determining the marketing channel, price spread analysis and studying the system of market intelligence would be initiated for coconut, arecanut and cocoa.

viii) Transfer of Technology:

The Institute has developed many technologies for improving the production and productivity of coconut, arecanut and cocoa. Large scale field adoption of these has been rather slow due to several constraints. In this context, strengthening the linkages between research organizations like CPCRI and SAUs and developmental agencies such as CDB, Directorate of Arecanut, Cocoa and Spices Development and State Departments of Agriculture/ Horticulture is of paramount importance. Organization of training programmes for officials of developmental agencies is, thus one of the important functions of the Transfer of Technology wing of the Institute. The Institute organizes regular training programmes on various aspects such as management of coconut and arecanut gardens, hybridization techniques, disease and pest management, post harvest technology and perennial crop based farming systems. The programmes are also organized for the farmers, private agencies and officers from other coconut growing countries. The ongoing training programmes will continue to be organized, besides need based specialized short term courses.

It is also proposed to establish a Trainers Training Centre in collaboration with the National Research Centres for Cashew and Oil palm to cater to the needs of trainers and subject matter specialists to acquaint them with the latest developments in different fields.

Direct involvement in technology transfer to the growers is also important for studying the adaptability of technologies developed under farmers' field conditions and for getting feedback. For this purpose, it is planned to layout research-cum-demonstration plots, strengthen the advisory services, establish mobile coconut/arecanut clinics, organize one or two day training programmes, besides popularization of technologies through mass media.

ix) Research on extension strategies:

Rapid changes are taking place in the society in its structure, functions, institutions and values as a result of technological revolution, migration, etc. The future extension research is to focus on the changes in society and to identify appropriate extension strategies to diffuse the technology in future social systems. In-depth studies on diffusion - adoption process, communication/extension methods, linkages, group dynamics etc with emphasis on farming systems research methods will also be taken up. The Institute is planning to initiate studies to assess the training needs of farmers and other developmental agencies in various aspects of coconut, arecanut and cocoa. Impact studies on various developmental programmes of both Central and State Governments are also envisaged.

The details of the objectives, goals and time scale of these programmes are as follows:

9.1 Setting of Programmes on a Time Scale

Sl.No.	Objectives	Goals	Time scale
1)	Collection and conservation of palm and cocoa germplasm		
	a) Survey and collection of indigenous germplasm	To survey and collect germplasm from Andaman and Nicobar Islands, Lakshadweep and North Eastern states	2000
	b) To survey and collect coconut germplasm from Indian Ocean Islands and South East Asia	To assemble the world coconut germplasm and setting up of the Regional Gene Bank for South-East Asia	2000
	c) Enriching arecanut germplasm Sri Lanka	Collection from Burma, East Indies and	2005
	d) Enriching cocoa germplasm	Obtain germplasm from Ghana, Brazil etc	2005
	e) Evaluation of germplasm of coconut, arecanut and cocoa	To select high yielding types resistant to diseases, pests, drought etc.	2020
2.	Crop Improvement		
	a) Resistance breeding for root (wilt) disease and drought in coconut high yield and tolerance to drought	To evolve high yielding varieties tolerant to root (wilt) disease and varieties with	2015
	b) Evolving high yielding dwarf varieties in arecanut	Evolving high yielding dwarf arecanut types	2020
	c) Varietal improvement in cocoa	Evolving newer hybrids with cross compatibility and high yield and resistant to drought and black pod	2020

Sl.No.	Objectives	Goals	Time scale
3.	Basic studies on tissue culture and developing a protocol for somatic embryogenesis and clonal multipli-cation in coconut	To develop clonal plantlets of high yielding varieties and hybrids to meet the planting material requirement	2020
4.	To identify compatible palm based cropping systems for various agro-climatic conditions to obtain maximum income from unit area	To understand the canopy structure, light penetration & root spread of various component crops and input requirement in the farming system	2020
5.	To determine the optimum nutritional input for coconut, arecanut and palm based cropping systems	To find out the optimum fertilizer dosage required for high yielding varieties of coconut, arecanut and cocoa, and palm based cropping systems	2020
6.	To develop an ideal irrigation system and water requirement for coconut, arecanut and cocoa and palm based cropping systems	To design and develop efficient irrigation system for palms and cocoa	2020 (Long term)
7.	To find out different physiological parameters for maximum productivity and also ideal canopy structure	To develop plant ideotype for high productivity	2020 (Long term)
8.	To establish the relationship between root (wilt) disease and leaf rot, if any, & to understand inter-relationship among root (wilt) disease of coconut, yellow leaf disease of arecanut and spear rot of oil palm	By cross inoculation studies and trans-mission trials the inter-relationship among root(wilt) disease, yellow leaf disease and spear rot will be established	Long term

Sl.No.	Objectives	Goals	Time scale
9.	To develop a technique for culturing of Phytoplasma, early diagnostic technique and refining the ELISA technique (wilt) disease	To develop effective management technique for Phytoplasma disease of palms and also screening coconut seedlings for root	Long term
10.	Forecasting the incidence of bud rot in coconut, mahali in arecanut and pod rot in cocoa and screening newer fungicides against the Phytophthora diseases. The inter-relationship of different species of Phytophthora infecting component crops in palm based cropping system is also proposed to be studied	To know in advance the occurrence of Phytophthora diseases so that timely prophylactic control measures can be adopted	2010
11.	To gather information on residual toxicity of the newer pesticides used in plantation crops	To estimate the residual toxicity in the edible parts/ the final product of palms and cocoa	2015
12.	To find out an effective early detection method coupled with biocontrol measures for red palm weevil use of synthetic pheromones	The red palm weevil causes serious crop loss in coconut. The goal is to develop an IPM technique involving biocontrol measures and	2010.
13.	To estimate the extent of crop loss caused by diseases such as Ganoderma wilt, stem bleeding and Thatipaka disease of coconut, koleroga of arecanut and pod rot of cocoa	By conducting systematic surveys, the crop loss caused by these diseases and the economic threshold at which plant protection measures are to be followed in different areas of occurrence are proposed to be estimated	2005

Sl.No.	Objectives	Goals	Time scale
14.	To estimate the cost of production of coconut, arecanut and cocoa	To have a realistic estimate of cost of production for making recommendations regarding incentives to be given to farmers and price support mechanism for stabilizing prices of commodities	2000
15.	To mechanize the operations such as harvesting of coconut, dehusking of coconut and arecanut, spraying fungicides on the crown of palms, base opening in coconut, and for inter-culture and post-harvest processing	Developing labour saving farm machineries to reduce the cost of production of coconut, arecanut and cocoa	2020
16.	To effectively utilize mature coconut timber emerging out of the replanting programmes particularly the senile and root (wilt) disease affected palms in Kerala.	Effective utilization of coconut timber for building material, furniture etc. so that the farmers will get remunerative prices for their uprooted coconut palms	Long term

9.2. Funding needs of the programme

Most of the funds required for various research projects envisaged earlier, particularly for research contingencies, strengthening infrastructural facilities, acquisition/replacement of instruments etc. are expected to be met from the regular budgetary allocations under plan and non-plan for the Institute in coming years. In addition, wherever possible the scientists will be encouraged to submit ad-hoc schemes to ICAR and other agencies/ organizations such as Coconut Development Board (CDB), Department of Biotechnology (DBT), United States Agency for International Development (USAID), International Plant Genetic Resources Institute (IBPGRI) to obtain needed funds for specific research programmes.

Some of the research programmes for which additional funds are required from external sources are indicated below.1) Support of development agencies such as CDB and Department of Agriculture are required for expanding the programme on resistance breeding in coconut to locate resistant/tolerant types and for extensive field testing against the root (wilt) disease. This work which has shown some encouraging results, is required to be expanded on a massive scale to build up adequate populations of tolerant material for supply of seedlings to farmers

2) Collection of coconut germplasm from Indian Ocean islands, African region, South East Asia and some of the Pacific Ocean islands is another priority area which needs funding from international organizations like IPGRI through the Coconut Genetics Resources Network (COGENT). COGENT is also expected to make a substantial contribution for establishing a regional gene bank for coconut at the Kidu farm. Similar support may also be required for cocoa and arecanut germplasm collections.

3) The Institute is also planning to establish advance centres of research for (i) Phytoplasma diseases of palms, (ii) biological control (iii) plant physiology and (iv) pesticide residue laboratory during the IX Plan. Each of these advanced centres may require about Rs.300 lakhs towards the purchase of instruments and buildings.

4) Additional funds are required for training the scientists as well as establishing/upgrading the laboratory facilities in frontier areas of research such as DNA finger printing and genetic engineering for which funds will be solicited from DBT, NARP etc.

5) At present, the Institute has only modest facilities to conduct research on post harvest technology and related fields. Massive investments in the form of additional manpower, laboratory and workshop facilities are required to intensify the research work on byproduct utilization and product diversification in coconut.

6) Additional funds are also needed for modernizing the library facilities.

9.3 Linkages, Co-ordination and Execution arrangements

9.3.1 Linkage

a) International

Effective formal linkages have been established with the Asian and Pacific Coconut Community (APCC), Jakarta and Coconut Genetic Resources Net Work (COGENT) of IPGRI, the two important international organizations involved in coconut research and development. The Bureau for the Development of Research on Tropical Perennial Oil Crops (BUROTROP) also plays an active role in coconut development. In addition, there are many national level research Institutes engaged in coconut research such as Coconut Research Institute, Lunuwila (Sri Lanka), IRHO, Paris/Montpellier Cedex (France), Coconut Research Institute, Manado (Indonesia), IRHO/CIRAD, Abidjan (Ivory Coast), Malaysian Agricultural Research and Developmental Institute (MARDI), Hilirperak(Malaysia) and Philippines Coconut Authority (PCA), Manila (The Philippines). Coconut research is also conducted in many Pacific Ocean Islands like Vanuatu, Solomon islands, Western Samoa, Tonga and Kiribati besides Tanzania, Nigeria, Brazil, Thailand and Papua New Guinea. Australian Centre for International Agricultural Research (ACIAR), Canberra(Australia), Wye College, London and Overseas Development and Natural Resources Institute, Kent (UK) also have active research programmes on coconut tissue culture, crop protection and post harvest technology.

While formal linkages with COGENT and APCC already exist, informal linkages with most of the coconut research Institutes also exist. These linkages need to be further strengthened for exchange of expertise and information. The linkages with COGENT and Pacific Ocean and Indian Ocean islands are required for further enriching the germplasm collections available at the Institute. Exchange programmes with the Philippines will give a boost to research on coconut timber utilization. Linkages with organizations like Wye college, ODNRI, IRHO and ACIAR are needed for advance training in biotechnology, processing and product diversification and disease management. A regional coconut germplasm centre for South Asia is also likely to be established at CPCRI, in its Kidu seed farm.

b) National

Effective linkages between CPCRI and State Agricultural Universities already exist through the AICRP on Palms. In addition collaborative research programmes with Kerala Agricultural University are being planned in the fields of root(wilt) disease, coconut based farming systems and crop management. Similar programmes are proposed to be taken up with the agricultural universities in Tamil Nadu, Andhra Pradesh and Karnataka. For germplasm collection and enrichment, joint programmes will be initiated with NBPGR. In the field of water management, linkages with other horticultural research institutes of the ICAR and Centre for Water Resources Development and Management, Calicut is being planned through a net work programme on drip irrigation and fertigation. In addition, collaboration with CSIR Institutes like Regional Research Laboratory, Trivandrum and CFTRI, Mysore and CIAE, Bhopal are desirable in the fields of post harvest technology and product diversification. In the field of biotechnology, linkages with the Department of Biotechnology, National Chemical Laboratory, Pune the Central University of Hyderabad and Baba Atomic Research Centre are needed for exchange of expertise and to avoid duplication. In the field of social sciences it is desirable to have linkage with the Centre for Development Studies, Trivandrum.

For extension and developmental activities the Institute has active linkages with Coconut Development Board, Directorate of Cocoa, Arecanut and Spices Development and State Departments of Agriculture/Horticulture.

9.3.2 Coordination Arrangements

The Central Plantation Crops Research Institute is also the headquarters of the All India Coordinated Research Projects on Palms. The Project Coordinator (Palms) placed at Kasaragod is responsible for coordinating the research programmes on coconut, oil palm and palmyrah in the State Agricultural Universities under the AICRP on Palms. This research net work coordination is being monitored at the Council's headquarters by ADG(PC) and DDG (Hort.). The Director, CPCRI is also a member of the Steering Committee of the Coconut Genetic Resources Network (COGENT) representing South Asia and plays an active role in the COGENT programmes. Coordination between the national programmes and international organizations is being done at the Council's level directly under the guidance of DDG (Hort.).

9.3.3 Execution Arrangements

The programmes identified earlier will be implemented at CPCRI, Kasaragod, its regional stations and research centres under the guidance and supervision of the Director. The Heads of Divisions and Regional Stations will assist the Director in the above task. Project leaders, who are the Principal Investigators of the research projects will be directly responsible for executing the technical programmes. Research in the SAUs on these crops will be executed under the AICRP on Palms and coordinated by the Project Coordinator (Palms).

Collaboration between CPCRI and other research institutes/international organizations should be executed through the ICAR/DARE as decided in multilateral/bilateral agreements and with the support of international agencies, wherever possible.

9.4 Critical Inputs

Most of the infrastructural facilities required for carrying out the research programmes contemplated are already available at the Headquarters and the regional stations/research centres of the Institute. However, there is an urgent need to acquire additional land for laying out systematic trials on the evaluation of existing germplasm, planting the new accessions proposed to be collected from outside the country, testing of new cross combinations, etc and for conducting agronomic experiments. Due to the wider spacing recommended for these crops and their perennial nature, large areas are required for field experimentation.

The ICAR should also take immediate decision regarding the strengthening or closure of the research centres. If the research centres are to continue under CPCRI/ICAR, additional manpower and facilities must be provided.

9.4.1 Funding

Only limited funds were made available during VIII Plan for modernization of laboratories and acquisition of new equipments. While it is proposed to establish advanced centres in biocontrol and Phytoplasma diseases and a new pesticide residue laboratory, the requirements of other divisions/sections should not be overlooked.

In recent years, the Institute was forced to stop subscription to several international journals and could not purchase new books due to budgetary constraints. This situation needs to be reversed. The library facilities are also required to be upgraded to international standards.

As discussed earlier to achieve the various objectives set forth for the Institute, adequate funds are to be made available. However the actual quantum of funds will depend on several factors such as fluctuations in foreign exchange rate, increase in the salaries etc. which are beyond the control of the Institute. However it has been tentatively estimated that the requirement of funds during the IX Plan period for the Institute (both plan and non plan) will be around Rs. 66 crores. The funds are mostly required for upgrading the existing laboratory facilities, establishing advanced centers and strengthening of infrastructural facilities such as office and laboratory buildings, additional staff quarters, library building etc.

9.4.2. Manpower

The present sanctioned staff strength of the Institute (including that of KVK) is 113 scientific, 166 technical, 112 administrative, 26 auxiliary and 532 supporting staff. No increase in sanctioned staff strength is envisaged in the coming years. However, redeployment of the scientists among the different disciplines will be made from time to time according to the requirements. Additional scientific man power in the form of Research Associates/Research Fellows will also be available to carry out the programmes planned under ad-hoc schemes.

9.4.2.1. Human Resources Development

The scientists of the Institute rarely get a chance to get advanced training in frontier areas of research. Only during the last few years some scientists could get training in fields like biotechnology and coconut genetic resources. Advanced training is required in the following fields.

1. Coconut timber utilization - Training in the Philippines

2. Post harvest technology and product diversification-Training at ODNRI, UK and Philippine Coconut Authority.

3. Drip irrigation, fertigation and water management - Israel and Centre for Integrated Land, Soil and Water Research, Wageningen, Netherlands.

4. Genetic resources information and management systems- University of Birmingham, UK.

5. Studies on integrated pest management and pheromones- ODNRI and Rothamstead Experiment Station, UK.

6. Developing modeling and computer simulation techniques for cropping systems, crop weather studies and soil water use Wageningen, Netherlands and USA.

7. Investigations on VAM in perennial crops- Laboratoire de Phytoparasitologie, Dijon Cedax, France

8. Advanced training on indexing Phytoplasma of coconut and arecanut- UK and Australia

9. Biotechnology- IRHO, Paris

9.5 Risk Analysis

Coconut is an economically important crop in several developing countries, which earn almost all of their foreign exchange resources through export of coconut and coconut products. This calls for enhanced South-South cooperation which may not be always advantageous to our country as the likely benefits could be offset/overshadowed due to increased competition from these countries in areas like coir industry in which India enjoys a pre-eminent position at present. Therefore collaborative programmes need to be identified very carefully.

Adequate precautions are required to be taken, while exchanging germplasm and breeding materials to avoid accidental introduction of serious coconut diseases like cadang cadang and red ring or any other unknown malady.

Wherever necessary, marketing infrastructure facilities and price support mechanisms are to be made available to the farmers. If not, higher production may result in lower prices and reduced income to the farmers. This has happened in the case of coconut in the past. In cocoa, many progressive farmers who had taken up cocoa cultivation with zeal had to destroy their produce and even cut trees as the few companies, which were in the field imported their requirements and stopped the purchase of indigenous production on one pretext or other.

9.6 Out put and Expected Situation

At the end of the programme envisaged, it is expected that the high yielding varieties/hybrids and various production, protection and post harvest technologies will help to increase the annual production of coconuts to over 20 million nuts. To cope up with the expected increase in coconut production, it is essential to achieve product diversification and byproduct utilization on a commercial scale. While product diversification will help to maintain sustained aggregate demand and higher income through value added projects, byproduct utilization will help to provide additional returns to the farmers.

India was importing large quantities of arecanut in 1950's. The quantity of imports came down gradually and since 1971-72 our country started exporting arecanut and it had shown a marginal increase between 1977 and 1992. However, the export of arecanut is not significant to warrant any change in the production target and to expand arecanut industry.

The research programmes envisaged on cocoa will help not only to improve the production of cocoa beans in the country, but also to improve the quality of indigenous beans. This will help the country to achieve self sufficiency.

10. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The progress of the research projects are being reviewed in the staff research council meetings which will be held twice a year. In addition, the Research Advisory Committee (RAC) constituted by the Director General (ICAR) will also review the research progress and suggest future lines of work. The Director and Heads of the divisions will monitor the progress of work from time to time by conducting mid term review meetings and periodical visits to the different Centres. As per the ICAR guidelines the progress of work will be reported through quarterly and annual reports. As in the past, the ICAR may appoint a quinquennial review team to evaluate the performance of the Institute.

11. RESOURCE GENERATION

The Institute is planning to convert its Research Centres at Kannara, Hirehalli and Kahikuchi into seed farms for production of elite planting materials. During 1996-97 about 50% of the cultivable area in these centres will be planted with parental lines for strengthening the seed production programmes. It is expected that the revenue from these three centres after a decade when the seed nut/seedling production can be started and from the seed farm at Kidu, will be around Rs. 10 million per annum. This will help to meet about five per cent of its total annual budget through the sales of elite planting materials. The Institute will also be offering consultancy services to earn additional revenue. In future patenting will be done for the technologies developed in bio-technology and post harvest technology and efforts would be made to earn royalty income by the sale of the patented technologies. In addition attempts will be made to generate additional resources by charging fees for the training courses offered by the Institute.

Allocation from the Indian Council of Agricultural Research (ICAR) under the plan and non-plan will continue to be the major source of funding for the Institute. Attempts also will be made to generate resources from external agencies like CDB, DBT, NARP, IBPGR, COGENT etc. for specific research programmes. The crops dealt by the Institute are commercial ones of perennial nature and with the new guidelines issued by the council, additional resource generation is possible through the sale of farm produce. .pa

12. PROGRAMME AND BUDGET

12.1 Major Programmes during IX Plan

1) *Collection and conservation of palms and cocoa germplasm*

   a) Survey and collection of coconut germplasm from Andaman & Nicobar Islands, Lakshadweep and North Eastern States, and Indian Ocean Islands and South East Asia and setting up of the Regional Gene Bank for South-East Asia.

   b) Enriching arecanut germplasm through collections from Myanmar, East Indies and Sri Lanka

   c) Enriching cocoa germplasm from Ghana, Brazil etc.

2) *Crop Improvement*

   a) Resistance breeding to evolve varieties tolerant to root (wilt) disease and drought in coconut

   b) Evolving high yielding dwarf varieties in arecanut

   c) Varietal improvement in cocoa to develop varieties with high yield, cross compatibility and resistance to drought and black pod

   d) Basic studies on tissue culture and developing a protocol for somatic embryogenesis and clonal multiplication in coconut

3) *Crop management*

   a) Developing an ideal irrigation system and determining the water requirement for coconut, arecanut and cocoa and palm based cropping systems

   b) Studies on fertigation in coconut and arecanut

   c) Studies on organic farming technology for the mandate crops through composting, vermi-composting, mushroom culture using farm waste and utilizing the remaining substrate as manure, VAM symbiosis etc.

4) *Crop Protection*

   a) Studies on the relationship between root(wilt) disease and leaf rot, and inter-relationship among root(wilt) disease of coconut, yellow leaf disease of arecanut and spear rot of oil palm

b) Developing a technique for culturing of Phytoplasma, early diagnostic technique and refining the ELISA technique

c) Studies on the inter-relationship among different species of Phytophthora infecting component crops in palm based cropping systems and screening of newer fungicides against Phytophthora

d) Studies on residual toxicity of the pesticides used in plantation crops

e) Developing an effective early detection method coupled with biocontrol measures for red palm weevil

f) Estimation of crop loss caused by diseases such as Root (wilt), Ganoderma wilt, stem bleeding and Thatipaka disease of coconut, koleroga of arecanut and pod rot of cocoa and major pests

g) Studies on integrated nematode management in palm based cropping systems

5) *Social Sciences*

a) Estimation of the cost of production of coconut, areca- nut and cocoa

6) *Post Harvest Technology*

a) Designing machinery to mechanize operations like harvesting of coconut, dehusking of coconut and arecanut, spraying fungicides on the crown of arecanut, base opening in coconut and post harvest processing

b) Studies on processing and utilization of coconut timber

Discipline wise revised cadre strength of Scientists

Sl.No	Discipline	Scientists	Senior Scientists	Principal Scientists	Total
01	Agronomy	07	03	01	11
02	Agricultural Entomology	08	01	-	09
03	Agricultural Economics	03	-	01	04
04	Agricultural Statistics	04	-	01	05
05	Computer Application	01	-	-	01
06	Agricultural Extension	03	01	-	04
07	Agricultural Engineering (Farm Machinery & Power)	01	-	-	01
08	Agricultural Engineering (Agrl.Structures & Processing Engineering)	01	-	-	01
09	Agricultural Chemistry	-	-	-	-
10	Biochemistry (Plant Sciences)	05	-	-	05
11	Biotechnology	04	-	-	04
12	Genetics & Cytogenetics	-	01	-	01
13	Horticulture	09	07	05	21
14	Microbiology (Plant Sciences)	04	-	-	04
15	Nematology	02	02	01	05
16	Plant Breeding	06	03	01	10
17	Plant Pathology	09	03	01	13
18	Plant Physiology	02	01	01	04
19	Soil Science	04	01	01	06
20	Mechanical Engineering	-	-	01	01
21	Electronic Engineering	-	01	-	01
22	Soil & Water Conservation Engineering	01	-	-	01
23	Economic Botany	01	-	-	01
	TOTAL	**75**	**25**	**13**	**113**

Area, production and productivity of coconut, arecanut and cocoa in India

Crop/years	Area	Production	Productivity
A. Coconut	**(million ha)**	**(million nuts)**	**(nuts/ha)**
1972-73	1.09	5997.20	5456
1977-78	1.06	5412.60	5123
1982-83	1.15	6356.10	5531
1987-88	1.34	7269.90	5401
1992-93	1.62	11375.60	7032
1993-94	1.63	12355.00	7579
1994-95	1.69	13230.70	7807
B. Arecanut	**(million ha)**	**(million tonnes)**	**(tonnes/ha)**
1972-73	0.176	0.151	0.86
1977-78	0.170	0.175	0.97
1982-83	0.180	0.184	1.02
1987-88	0.200	0.228	1.14
1992-93	0.220	0.248	1.13
1993-94	0.235	0.275	1.17
1994-95	0.235	0.272	1.16
C. Cocoa	**(million ha)**	**(million tonnes)**	**(tonnes/ha)**
1983-84	0.022	0.0056	0.254
1987-88	0.018	0.0075	0.416
1992-93	0.012	0.0068	0.566
1993-94	0.011	0.0067	0.605

ANNEXURE III

Compound growth rates of area, production and productivity of coconut, arecanut and cocoa in India

S.No	Crop/ Period	Compound growth rates in Area	Production	Productivity
1.	**Coconut**			
	1973-74 to 1982-83	0.18	0.14	-0.03
	1983-84 to 1994-95	3.97	7.43	3.35
2	**Arecanut**			
	1973-74 to 1982-83	0.02	2.44	2.43
	1983-84 to 1994-95	2.36	2.87	0.56
3	**Cocoa**			
	1983-84 to 1993-94	-5.99	1.30	7.77

ANNEXURE IV

Export of coir and coir based products from India

(value in million rupees)

S.No	Particulars	1992-93	1993-94	1994-95
01	coir fibre	0.46	0.19	7.69
02	coir yarn	196.60	263.70	348.80
03	coir mat	508.20	689.20	804.80
04	coir matting	177.60	231.80	358.60
05	coir rugs & carpet	236.50	83.93	142.00
06	coir rope	1.38	6.31	1.66
07	curled coir	9.02	4.93	18.60
08	rubberized coir	7.15	9.90	11.09
09	coir geotextiles	-	-	15.13
10	coir pith	0.18	0.23	0.64
11	coir other sorts	1.51	3.46	1.51
	Total	**959.53**	**1293.67**	**1716.40**