CPCRI Perspective Plan

VISION-2025

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

CPCRI *Perspective Plan*

VISION -2025

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FOREWORD

Indian agriculture must continuously evolve to remain ever responsive to manage the change and to meet the growing and diversified needs of different stakeholders in the entire production to consumption chain. In order to capitalize on the opportunities and to convert weaknesses into opportunities, we at the ICAR attempted to visualize an alternative agricultural scenario from present to twenty years hence. In this endeavour, an in-depth analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) was undertaken to place our research and technology development efforts in perspective so that we succeed in our pursuit of doing better than the best. Accordingly, the researchable issues are identified, strategies drawn and programmes indicated to have commensurate projects and relevant activities coinciding with the launch of 11th Five Year Plan.

Central Plantation Crops Research Institute deals with the research and front line extension aspects mainly of coconut, arecanut and cocoa to increase the production and productivity in a sustainable manner. Keeping in view the emerging trends, research on plantation crops needs to be intensified and new initiatives undertaken in the mandate crops, towards the development of resistant varieties for the disease and drought management. The application of molecular tools has become imminent to address the various problems. The focus on cropping/farming system research could help in development of more sustainable systems models by including compatible high value, low volume crops to increase the profitability. Research on development of effective formulations of agriculturally important micro-organisms viz. nitrogen fixers, phosphate solubilisers, plant growth promoting rhizobacteria (PGPR), arbuscular mycorrhizae and organic matter decomposers, substrate dynamic studies and their applications would help to meet the nutritional requirement and achieve better input use efficiency. Thrust is also given to product diversification and value addition with a view to exploiting the potential available to enhance the net returns from the holdings.

It is expected that realizing the Vision embodied in the document would further ensure that the CPCRI, Kasaragod continues to fulfill its mandate to make Indian agriculture locally, regionally and globally competitive. The efforts and valuable inputs provided by my colleagues at the ICAR Headquarters and by the Director and his team at the Institute level for over an year to develop Vision 2025 deserve appreciation.

(MANGALA RAI)

Secretary, Department of Agricultural Research & Education

and

Director General, Indian Council of Agricultural Research

Dr. Rajendra Prasad Road, Krishi Bhavan, New Delhi -110 001, India

February, 2007

PREFACE

Coconut, arecanut and cocoa are small land holder's plantation crops cultivated in India. The country's annual production of coconut is to the tune of 12833 million nuts from an area of 19.35 lakh hectares. At present India produces 4.39 lakh MT of arecanut from an area of 3.64 lakh ha. Cocoa crop is cultivated in about 29471 ha and the annual production is about 10,175 MT with a productivity of 530 kg/ha.

The Central Plantation Crops Research Institute (CPCRI), was established in 1970 as one of the research institutes under Indian Council of Agricultural Research (ICAR) with Kasaragod as headquarters and the mandate to work on coconut, arecanut, cocoa, cashew, oil palm and spices. The research on cashew, spices and oil palm was delinked from CPCRI with the establishment of separate Institutes/National Research Centres from the VIIIth plan period onwards. The institute has the mandate now to conduct basic, strategic and applied research on coconut, arecanut and cocoa and has three regional stations and four research centers located in different parts of the country. The International Coconut Gene Bank for South Asia (ICG-SA) is located at Research Centre, Kidu, Karnataka. The institute also houses the head quarters of All India Co-ordinated Research Project (AICRP) on Palms. Through systematic research over several decades, CPCRI has been able to generate substantial number of technologies on palms and cocoa with high production potential benefiting the farming community. The achievements of the institute in areas such as biotechnology and crop improvement, production and protection, natural resource management, post harvest technology and value addition and technology transfer are well recognized.

Growth in income, particularly in developing countries is anticipated to lead to an increase in demand for various products. Global Gross Domestic Product (GDP) has increased by nearly 87 per cent over the past 25 years and is predicted to continue rising by 40 per cent by 2010 despite threats of downturn in global economy. The per capita GDP is expected to rise by more than 20 per cent and as per capita income increases so will per capita consumption.

The Perspective Plan of CPCRI – Vision 2025 has been prepared taking into account the past achievements, present and emerging scenario and SWOT analysis, issues and challenges faced by the mandate crops. Looking at the changing global environment, the perspectives and the future research and development strategies have been formulated by identifying new programmes in frontier areas and reprioritizing the existing programmes to develop sustainable production systems which are globally competitive. The programmes envisaged in this document will be executed successfully to achieve the vision "RESEARCH AND EXTENSION FOR ACHIEVING COMPETITIVENESS THROUGH HIGHER PRODUCTIVITY" in the long run.

I am thankfull to Dr. Mangala Rai, Secretary DARE, and Director General, ICAR, for his constant guidance and encouragement to bring out this document in the present form. I thank all the scientists and staff in the PME Section of the institute for the valuable help rendered in the preparation of this vision document.

(George V. Thomas)
Director
Central Plantation Crops Research Institute
Kasaragod, Kerala

EXPLANATION TO THE ABBREVIATIONS

ADB	Asian Development Bank
ADOT	Andaman Ordinary Tall
AFLP	Amplified Fragment Length Polymorphism
AICRP Palms	All India Coordinated Research Project on Palms
AIMs	Agriculturally Important Microorganisms
APCC	Asian & Pacific Coconut Community
ARIS	Agricultural Research Information System
ATIC	Agricultural Technology Information Centre
BSNL	Bharat Sanchar Nigam Ltd.
BTC	Break Through Curve
C:N	Carbon : Nitrogen
CA	Conservation Agriculture
CCMB	Centre for Cellular and Molecular Biology
CDB	Coconut Development Board
CD-ROMs	Compact Disc – Read Only Memory
CGD	Chowghat Green Dwarf
CGRD	Coconut Genetic Resources Database
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement
CIRCOT	Central Institute for Research on Cotton Technology
COD	Chowghat Orange Dwarf
COGENT	International Coconut Genetic Resources Network
CPCRI	Central Plantation Crops Research Institute
CRI- Sri Lanka	Coconut Research Institute – Sri Lanka
DAC	Direct Antigen-Coated
DAF	DNA Amplification Fingerprinting
DBT	Department of Biotechnology
DC	Desiccated Coconut
DCCD	Directorate of Cashew and Cocoa Development
DFID	Department for International Development
DNA	Deoxyribo Nucleic Acid
ELISA	Enzyme-Linked Immuno Sorbent Assay
EPN	Entomo Pathogenic Nematodes
EST	Expressed Sequence Tags

FJT	Fiji Tall
FMS	Federated Malay States
GBGD	Gangabondam Green Dwarf
HD	Hirehalli Dwarf
HDMSCS	High Density Multi Species Cropping System
IACR - Rothamsted	Institute for Arable Crops Research- Rothamsted
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IISR	Indian Institute of Spices Research
INARIS	Integrated National Agricultural Resources Information System
INM	Integrated Nutrient Management
IPGRI	International Plant Genetic Resources Institute
IPM	Integrated Pest Management
IPNMS	Integrated Plant Nutrient Management Systems
IRC	Institute Research Committee
ISR	Induced Systemic Resistance
ITC- The Netherlands	International Training Centre - The Netherlands
JAMT	Jamaica Tall
JVT	Java Tall
KCl	Potassium Chloride
LAN	Local Area Network
LCT	Laccadive Ordinary Tall
MGD	Malayan Green Dwarf
MYD	Malayan Yellow Dwarf
NATP	National Agricultural Technology Project
NC -COCOA	Nigerian Collection
NCBI - USA	National Center for Biotechnology Information - USA
NCBS	National Center for Biological Science
NGT	New Guinea Tall
NIC	National Informatics Centre
NRCC	National Research Centre for Cashew
PGPR	Plant Growth Promoting Rhizobacteria
PHOT	Philippines Ordinary Tall

PMT	Project Monitoring and Technical Cell
PTT	Participatory Technology Transfer
QTL	Quantitative Trait Loci
RAC	Research Advisory Committee
RAPD	Randam Amplified Polymorphic DNA
RFLP	Restriction fragment length polymorphism
RT- PCR	Reverse transcriptase Polymerase Chain reaction
RWD	Root (wilt) Disease
SAU	State Agricultural Universities
SBTN	Snow Ball Tender Nut
SHGs	Self Help Groups
SNP	Single Nucleotide Polymorphisms
SNRT	San Ramon Tall
SSGT	Straits Settlement Green Tall
SWOT	Strength Weakness Opportunity Threat
USA	United States of America
VSAT	Very Small Aperture Terminal
VSD	Vascular Streak Dieback
WCT	West Coast Tall
WTA	World Trade Agreement
WTO	World Trade Organization
WUE	Water Use Efficiency
YLD	Yellow Leaf Disease

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EXECUTIVE SUMMARY

The Central Plantation Crops Research Institute (CPCRI) was established in 1970 as one of the agricultural research institutes in the National Agricultural Research System under the Indian Council of Agricultural Research (ICAR). The Institute deals with the research and front line extension aspects of coconut, arecanut and cocoa under five broad Divisions of Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post Harvest Technology and Social Sciences. Institute has major mandate to develop modern technologies which will contribute towards increasing the production and productivity of the mandate crops in a sustainable manner. Thrust is also given to product diversification and value addition with a view to exploiting the potential available to enhance the net returns from the holdings.

Scenario analysis of the mandate crops has been done, issues identified and formulated the strategies and programmes to enhance the competitiveness of the crop. Coconut oil is one among the 17 oils and fats and is facing stiff competition from other vegetable oils like soybean and palm oil, which have shown faster growth rate in production and productivity in comparison with coconut. In the world coconut trade, the competing countries like the Philippines, have high export share (78.88%) than the internal consumption (21.12 %), whereas in India, the entire production goes for internal consumption.

Edible oil is a major component of the diet, and demand for fats and oils is increasing faster than the population growth. In the emerging scenario, as per-capita income increases the per-capita demand for vegetable oil also increases rapidly. To increase the competitiveness of coconut sector, there is urgent need to increase the productivity per unit input. Efforts should be focused on improving production and productivity, management of pests and diseases, narrowing down the gap between genetic potential of coconut and average farm yield, product diversification and finding alternative use of conventional products based on the market demand for coconut products. Efforts will be made to overcome the structural problems like large share of small holdings by adopting cluster approach and evolving group strategies.

The coconut price is largely decided by the single product coconut oil only. Product diversification based on market needs and on farm processing are the strategies to be focused to enhance profitability, employment generation and competitiveness of the crop.

The perspective plan of the institute has been prepared with a vision to make India a world leader in production and productivity of coconut, arecanut and cocoa. The vision statement of the perspective plan is "Research and extension for achieving competitiveness through higher productivity."

Keeping in view the emerging trends, research will be intensified and new initiatives undertaken in the mandate crops, towards the development of resistant varieties for the disease and drought management. Data base of genetic resources need to be developed for the better management of genetic resources to address the problems confronted by the crop. Application of association mapping, gene cloning and gene pyramiding approaches will enable to evolve stress tolerant genotypes. *In vitro* conservation of superior genotypes and cryopreservation of germplasm will be standardised as a disaster management strategy. Augmentation of quality planting material production would help narrow the supply gap. The focus on cropping/farming system research would help to evolve more sustainable systems models by including compatible high value, low volume crops to increase the profitability. Development of effective formulations of agriculturally important micro-organisms viz. nitrogen fixers, phosphate solubilisers, plant growth promoting rhizobacteria (PGPRs), Arbuscular mycorrhizae and organic matter decomposers, substrate dynamic studies and their applications would help to meet the nutritional requirement and achieve plant growth promotion for better input use efficiency. This will be achieved by molecular and microbiological studies to map the rich diversity of Agriculturally Important Microorganisms (AIMs) in the rhizosphere of the main crop and inter/mixed crops.

Product diversification of coconut and development of value added products would help to avoid dependency of coconut price only on coconut oil market. Market intelligence and policy research would keep the country in an advantageous position in the International trade arena.

The production and productivity of arecanut of Myanmar and Indonesia have shown rapid increase during last two decades. In the emerging scenario, these countries will compete with India in International and domestic market for arecanut.

Our major efforts will be directed towards reducing the cost of production per unit output. Research programmes will be strengthened on management of yellow leaf disease by development of resistant varieties and mass multiplication technique, production technologies with high input use efficiency, farming system approach, and finding alternate uses of arecanut for increasing the profitability for the farmers.

The production of cocoa beans hardly meets a small fraction of the industries demand in India. Efforts will be made to increase the productivity by developing innovative production, protection and processing technologies, and upgrading the processing technologies in the manufacture of chocolates and confectionery.

1. PREAMBLE

The Central Plantation Crops Research Institute (CPCRI) was established in 1970 as one of the agricultural research institutes in the National Agricultural Research System under the Indian Council of Agricultural Research (ICAR).

The Institute deals with the research and front line extension aspects of coconut, arecanut and cocoa under five broad Divisions of Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post Harvest Technology and Social Sciences. The Institute has three Regional Stations at Kayangulam (Kerala), Vittal (Karnataka) and Minicoy (Lakshadweep) and four Research Centres at Kahikuchi (Assam), Mohitnagar (West Bengal), Kidu (Karnataka) and Kannara (Kerala). The Institute has sound infra structural facilities like well established research farms, well equipped laboratories at Headquarters as well as Regional Stations and Research Centres and Library cum Documentation Centre. The Transfer of Technology of the Institute is carried out by adopting four faceted approaches in the form of the Extension Section, Agricultural Technology Information Centre, Krishi Vigyan Kendras (one each at Kasaragod and Kayangulam) and the Institution Village Linkage Programme. The Research Centre at Kidu helps to cater to the needs of the farmers by supplying elite planting materials of the mandate crops, in addition to the service as the Centre for International Coconut Gene Bank. The Perspective Plan of the institute has been prepared with the following vision and mission.

1.1. Vision

CPCRI with its research contributions and extension activities would help to make India a world leader in the production and productivity of coconut, arecanut and cocoa and would ensure that the country becomes competitive in international trade. The institute will lay special emphasis on enhancing income generation of farmers.

In nutshell, the vision statement of CPCRI's Perspective Plan is

"RESEARCH AND EXTENSION FOR ACHIEVING COMPETITIVENESS THROUGH HIGHER PRODUCTIVITY"

1.2. Mission

- Strengthening the biodiversity and biosecurity of mandate crops and their utilization for improving the productivity and income security of coconut, arecanut and cocoa growers.
- Protecting and improving the land, water, microbial and climate resources essential for sustained advances in the productivity, profitability and stability of palm based farming systems.
- Development of appropriate technologies which can help to attract entrepreneurs and can confer the empowerment of small and marginal farmers both in the production and post-harvest technologies, thereby enhancing their income and competitiveness.
- Enhancing the income, livelihood, nutrition and health security of farm families through mutually reinforcing package of technologies.

2. MANDATE

The Central Plantation Crops Research Institute has the major objective to conduct research on small holders' plantation crops viz. coconut, arecanut and cocoa. It is aimed at developing modern technologies which will contribute to increase in production and productivity of the mandate crops on a sustainable manner. Thrust is also given to product diversification and value addition with a view to exploit the potential available to enhance the net returns from the holdings. The Institute also serves as the headquarters of the All India Coordinated Research Project on Palms to coordinate research within the country on palm species such as coconut, oil palm and palmyrah.

Mandate

Consequent on the delinking of research on cashew and spices in 1986 and oilpalm in 1998 from CPCRI, the Institute now has three mandatory crops – coconut, arecanut and cocoa. The mandate is as follows:

1. To develop appropriate production, protection and processing technologies for coconut, 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.

3. GROWTH

3.1. Infrastructure

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, 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 expanded the LAN facility to all the Divisions/Sections, with optical fiber cabling as backbone between buildings. There are 82 computers including 7 Sever class machines installed in various Divisions. Internet, file and printer sharing facilities are provided to all terminals. The Institute is having VSAT connectivity through NIC as well as leased line connectivity through BSNL. The three proxy servers installed in the ARIS Cell ensures uninterrupted connectivity to all terminals, 24 hours a day. ARIS Cell is also providing remote scanning and network printing facilities.

The following are the main web sites maintained by the Institute:

1. http://www.cpcri.gov.in/
2. http://www.bioinfcpcri.org/
3. http://www.cpcri.ernet.in/

There are 34 laser printers, 24 desk jet printers, 28 Dot-matrix printers and 16 Flat bed scanners available in the Institute.

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.

Land

Details of land available in different stations, centres of CPCRI

Sl. No.	Place	Total area (ha)	Cultivable area (ha)
1	HQ - Kasaragod	77.86	59.15
2	Regional Station, Kayangulam	24.17	21.00
3	Regional Station, Vittal	68.34	57.34
4	Regional Station, Minicoy	5.70	4.75
5	Research Centre, Kannara	14.20	13.00
6	Research Centre. Mohitnagar	25.99	20.80
7	Research Centre, Kahikuchi	15.76	8.00
8	Research Centre, Kidu	120.00	113.00
Total		**352.02**	**297.04**

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, Pathology, Microbioloty, 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, Agro-processing Centre, Farm Office, Stores and mixed farming unit. There are separate buildings with modern facilities for Agricultural Technology Information Centre (ATIC), Library and Information Centre, and Agricultural Research Information Systems (ARIS). Molecular biology laboratory, vedio conferencing system and Open Top Chamber for elevated CO_2 studies are recent additions. The Institute also has three guest houses and one hostel and about 100 residential quarters of various categories.

At the Regional Station Kayangulam, the main building houses the Head's office, technical section, Statistics, Library, Agronomy, Extension, 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 bio-control 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 guesthouse, farm office and stores buildings. The Regional Stations at Minicoy in Lakshadweep Islands has a Laboratory-cum-Administrative building. The other research centres at Mohitnagar, Kahikuchi and Kannara have modest administrative-cum-laboratory buildings. The farm office at Kidu Research Centre is located in a semi permanent structure. The centres at Kannara, Mohitnagar and Kidu have a limited number of residential quarters. Green house facilities and mist chamber are available at Mohitnagar and Kahikuchi centres. Mohitnagar centre has facilities for tissue culture work.

Library

The institute has good library facilities both at the head quarters at Kasaragod and the two regional stations at Kayangulam and Vittal. The holdings of various publications at various centers is given in the table below.

Library facilities at various centers

Station	Indian Jls.	For. Jls.	Back vol.	Books	Other doc.
Kasaragod	75	55	10437	8005	6770
Kayangulam	28	13	5839	3264	3200
Vittal	43	8	5104	5275	2353
Mohitnagar	4	-	-	221	24
Kahikuchi	8	-	-	43	55
Kidu	6	-	-	10	16
Total	164	76	21380	16818	12418

Library at the HQ has separate well furnished building with all latest facilities for information retrieval. The Library is automated with fully integrated multi user library software, Libsys, working under Windows NT.

Services offered

Library webpage

Library web page is accessible at the site http://bioinfcpcri.org where necessary links are provided by the library such as online journals, library catalogue, union catalogue of current and back volumes of journals, table of contents of foreign journals currently subscribed. In addition to this, study circle papers and official formats are also provided.

Access to databases subscribed / developed in-house

The full text as well as bibliographic databases developed by the Library are hosted through web server of the library with password restriction. The library has a 14 bay CD-server providing access to subscribed databases over LAN network.

Internet

256kbps Internet connectivity via BSNL leased line connection is provided over LAN and readers are allowed to utilise all services available over the internet.

Resource sharing

The libray has established a resource sharing programme with the neighbouring ICAR institutes viz. IISR, Calicut and NRCC, Puttur to avoid wasteful expenditure and to ensure efficient utilization of funds. In this effort, the library makes available the table of contents of foreign journals subscribed over the institute web page with facility to make online request for articles and online delivery. The union catalogue of CD-ROMs as well as journals subscribed at CPCRI, IISR and NRCC is also hosted on the library website.

Exchange of publications

Library exchanges the institute annual reports and research highlights to ICAR institutes, universities, departments of agriculture, plantation commodity boards and international institutes

Glimpse

A newspaper clippings service " The Glimpse " covering news items related to agriculture / plantation crops is brought out daily.

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)
IX Plan (Actuals)	1032.77 (45.14)	4468.56 (100.69)	5501.33 (87.24)
X Plan (Actuals)	1270.00 (22.97)	5868.24 (31.32)	7138.24 (29.75)
XI Plan (Projections)	3500.00 (175.59)	7000.00 (19.29)	10500.00 (47.10)

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

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

3.3. Manpower (Sanctioned)

Plan Period	Scientific	Technical	Administration	Auxiliary	Supporting	Canteen Staff
IV Plan	91	93	64	-	73	
V Plan	195 (114.3)	113 (21.5)	112 (75.0)	-	651 (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)	-
IX Plan (1997-2002) (31/3/2002)	105+1 (-6.2)	151 (-9.0)	96 (-14.3)	-	443 (-16.7)	16
X Plan (2002-2007 (As on 31/3/2007)	105+1	149 (-1.3)	91 (-5.2)	-	311 (-29.8)	11 (-31.3)

Note : Figures in parenthesis indicate percentage change (increase or decrease) over the previous plan period. The manpower in VIII Plan indicates KVK staff.
* Reduction in manpower during VII & VIII Plans is due to redeployment to established NRCs on Spices, Cashew & Oil palm.

4. SALIENT RESEARCH ACHIEVEMENTS

4.1. Crop Improvement

CPCRI maintains the largest germplasm collection of 364 coconut accessions, which includes 132 exotic and 232 indigenous collections. The International Coconut Gene bank for South Asia has been established at CPCRI RC, Kidu in 2001. So far 57 accessions have been planted in replicated blocks with a population size of 45-90 palms/accession and three replications. Characterization data of 74 accessions, covered in the Coconut Descriptors Part I and Part II has been submitted to CGRD.

In arecanut, the largest germplasm collection of 153 accessions which include 23 exotic and 130 indigenous areca types are conserved at the CPCRI, RS, Vittal and same are being evaluated for their yield performance and reaction to major diseases and pests. Descriptors on 'Areca palm' were prepared for 60 germplasm accessions of arecanut maintained at the Regional Station, Vittal based on 17 morphological, four inflorescence and 14 fruit component characteristics.

In cocoa, 185 accessions are conserved in the field Gene Bank at Regional Station, Vittal. Characterization of 19 collections of cocoa have been done based on the canopy and pod characters of the clones.

Three coconut hybrids and three varieties have been released from this institute. The hybrids released are WCT x COD (Kerasankara), COD x WCT (Chandrasankara) and LCT x WCT (Chandralaksha). Based on the evaluation and multilocational trials, two coconut varieties, LCT (Chandrakalpa) and PHOT (Kerachandra) have been released. Chowghat Orange Dwarf was released as variety for tendernut purpose.

Breeding programmes in the root (wilt) disease affected tract resulted in the development of the hybrid, CGD x WCT with relative tolerance to root (wilt) disease and high yield potential. Seed gardens have been established for large scale production of disease tolerant planting material.

Hybrid evaluation trial II for coconut was laid out in 1972 as a partial Diallel analysis (without reciprocals) involving WCT, LCT, SNRT, FJT, JAMT, JVT, GBGD, SSGT and NGT as parents and their 36 hybrids. Combining ability was analyzed for the nut yield in this trial. It was found that Laccadive Ordinary was the best general combiner and Laccadive Ordinary X Gangabondam (LCT x GBGD) was found to be the best specific combiner.

The arecanut germplasm evaluation and yield evaluation trials resulted in the release of four high yielding varieties, Mangala, Sumangala, Sreemangala and Mohitnagar. The evaluation of 71 different arecanut germplasm under Sub-Himalayan Terai conditions in North Bengal has been in progress since 1988. The breeding work to exploit the potential of dwarf arecanut revealed that the combinations HD x Sumangala (2.49kg), HD x Mohitnagar (2.59kg) and Mohitnagar x HD (2.65 kg) exhibited their superiority for chali yield/palm. Elite mother trees of cocoa have been identified for the generation of hybrids and based on the evaluation of F-1 progenies, four hybrids were identified for release.

Evaluation of cocoa germplasm planted during 1995 revealed that NC 52 clones had an annual pod yield of 60.50 followed by NC 22 with 53.75 and NC 50 with 45.63 pods. Among the 14 Lal Bagh clones, NA 242 clone maintained superiority over others in withstanding the naturally recurring stress due to alternate seepage of water and dry soil for 3 months each.

4.2. Biotechnology

Embryo culture

Embryo culture protocol was developed and standardized to retrieve coconut accessions from different places. Fifteen-coconut exotic germplasm were collected using this technique from Indian Ocean Islands *viz*., Mauritius, Madagascar, and Seychelles. This was the first time in the world that the germplasm was collected in the form of embryos. The retrieved plantlets were planted in ICG-SA Kidu.

Tissue culture

Regeneration of plantlet through somatic embryo genesis and meristemoids was achieved from Tall (WCT) and Dwarf (COD, MYD,CGD) plumular tissues by supplementation with polyamines (spermine and Putricine) and picloram in the culture medium. Coconut root cultures could be conserved for more than 2 years in slow growth culture media. Somatic embryogenesis was achieved for coconut and arecanut from leaf explants of 1-year-old seedling. Embryogenic calli and somatic embryo regeneration was obtained in inflorescence of adult explants.

DNA Fingerprinting of accessions

DNA extraction protocol from spindle leaf of coconut has been standardized. Partial genomic library of coconut was constructed by cloning 1-2 Kb Eco RI fragment of WCT DNA into plasmid PVC18 and transforming to *E. coli* DH5a. PCR conditions were standardized for RAPD analysis in coconut. Hundred 10-mer primers screened for detecting polymorphism between coconut accessions of which 8 primers detected polymorphism for RAPD analysis of coconut germplasm maintained at CPCRI.

RAPD fingerprints of 181 palms belonging to 58 accessions was developed based on the markers. Genetic distance was calculated and dendrogram was constructed. Populations of tall cultivars were more scattered and individual palms of many accessions did not group together indicating presence of diversity within and between accessions. Niu Leka Dwarf was found to be intermediate between talls and dwarfs. PCR conditions were standardized for microsatellite analysis and 46 coconut accessions (4-6 samples each) were analysed using 8 microsatellite primers. The within population diversity was 60% and between population variation was 40 %. The average gene diversity was 0.315.

Using DAF analysis, a putative marker for resistance to root (wilt) disease in coconut has been detected. DNA fingerprints have been developed for 76 cocoa accessions using RAPD markers. Based on the genetic distance four highly divergent accessions were identified, which could be useful to cocoa breeders in India to utilize these accessions for cocoa improvement.

Cryopreservation

Mature embryos of West Coast Tall variety of coconut could be cryopreserved after desiccation pre-treatment and retrieved into plantlets. Two types of desiccations were employed *viz*., Silica gel and laminar airflow methods. The maximum retrieval of healthy plantlets could be obtained only from the embryos subjected to 18 hours silica gel and 24 hours laminar airflow desiccation pre-treatment. Irreversible damage caused by desiccation leading to the death of the shoot meristem was noticed when the water content was reduced to 20 %.

4.3. Production System Management

Soil available P and available S were found to increase with increasing levels of sulphur application. In general, the available Ca and Mg content in the soil decreased with increasing the level of S application. Greater mobility was observed in the magnesium sulphate BTC as compared to ammonium sulphate. In the studies on the effect of potassium on the nutrition and productivity of coconut at 0,1,2,4 & 6 kg KCl/palm/yr it was observed that 2 kg KCl/palm/year gave the highest yield of 62 nuts/palm/year in the farmer’s field. Statistically no significance was observed in the different doses of K applied. However leaf K content and soil average K was observed to increase with increase in K application.

Nursery management techniques such as selection of garden, mother palm and seed nuts, planting and maintaining the nursery, and the technique for raising poly bag nursery were standardized. Square system of planting at a spacing of 7.5 x 7.5 m with a plant density of 175 palms/ha is recommended. Recomended dose of fertilizer for coconut palm is application of 500g N, 320g P_2O_5 and 1200g K_2O/ palm/ year in two split doses during September and May. Application of magnesium @500g MgO per palm was found to be advantageous in areas where palms show yellowing of leaves.

In boron nutrition studies, coconut seedlings suffering from boron deficiency could be recovered by application of 300g boron/seedling/year and application of 500 g boron was found to be effective in recovery of adult palms in root (wilt) affected area.

For coconut, drip irrigation system was found to be more advantageous under littoral sandy soil than lateritic soil, irrigating the palms with 66% of Eo (32 l/palm/day) was adequate to realise maximum yield. Fertigation studies in coconut have indicated that 50% NPK of the recommended dose through drip irrigation network has given the highest yield.

Arecanut varieties responded positively to higher fertilizer doses up to 200:80:240 g of N, P_20_5 and K_20/palm/year. From economic point of view, it is feasible to apply the above dose as it has resulted in higher benefit-cost ratio of 4.25, while benefit -cost ratio was 2.52 in no fertilizer treatment.

For arecanut, irrigation schedule is 200 lit of water per palm once in 6 days through hose. Drip irrigation @ 20 litres of water /palm/day can save 44 % of water. Fertigation studies in arecanut have indicated that 75% NPK of the recommended dose through drip irrigation network has given the highest yield.

Work on Bio-engineering's measures for soil and water conservation in the Western Ghat Region and water harvesting structure have been developed. In the soil and water conservation measures for coconut growing on sloppy terrains, growing CO 3 fodder grass in the interspaces of coconut along with a pineapple hedge was found to prevent soil erosion and water loss considerably.

A non-sequential irrigation system with an electronic tensiometer sensor system or alternatively with gypsum sensor system were designed at CPCRI. These systems have been field tested for their accuracy and have been found to work efficiently.

The technique for utilization of leguminous cover crops such as *Pueraria phaseoloides, Mimosa invisa* and *Calopogonium mucunoides, Cowpea* as green manures to supply biologically fixed nitrogen and easily decomposable biomass to coconut, to substitute for 50 % nitrogen fertilizer was standardized. A field experiment conducted in a coconut plantation in an acidic laterite soil type revealed the feasibility of substituting upto 50% of fertilizer nitrogen with the nitrogen contributed by leguminous green manures. *M. invisa* and *P. phaseoloides* are well nodulated by native rhizobia in acidic coconut soils. *Marasmiellus troyanus* and a local isolate of *Trichoderma* species were found effective for microbial composting of coir pith. Microbial enrichment of compost with N_2 -fixing bacteria and phosphate solubilisers was achieved.

Glyricidia leaf manure could substitute for 50% of urea in the management of coconut in coastal sandy soils. Field experiments on substitution of chemical fertilizers by composted coir pith indicated that the treatment NPK (50%) + composted coir pith (50%) gave highest yield of 104 nuts/palm/year followed by 100% NPK as inorganic fertilizer, which recorded 82 nuts/palm/year.

Coconut based cropping systems involving cultivation of compatible crops like tubers, flowering, medicinal and aromatic crops, fruits, vegetables, spice crops, in the interspaces of coconut was more remunerative compared to coconut monocropping. Coconut-based high-density multi-species cropping systems (HDMSCS) involving many crops like tapioca, elephant foot yam, colocasia, banana, pineapple, nutmeg, clove, pepper, etc. was established. Application of $2/3^{rd}$ of recommended dose fertilizer for coconut is sufficient under the system to attain maximum yield (151 nuts/palm/year) and return. The highest quantity of recyclable biomass (22.58 t/ha) was obtained at full fertilizer dose treatment compared to 17 t/ha in the control treatment. The total energy input (fertiliser, irrigation and manpower) into the coconut based cropping system has been worked out, which ranges from 17,02,233 to 17,12,294 MJ/ha. Allelopathic studies in coconut based cropping system with standardisation of extraction procedure for of coconut leaf and root leachates from young and adult palms were carried out. Laboratory bioassays to determine the allelopathic concentration of coconut root and leaf leachates through seedling vigour index method were initiated. Leaf and root leachates from adult WCT palm at 1:5 and 1:10 concentrations were found to be allelopathic to cow pea seedlings. *In vitro* studies indicated that the diazotrophs were sensitive to the coconut root and leaf leachates, while, the phosphate solubilizers and PGPRs got stimulated.

Growing feasible vegetable crops, soyabean, flower crops, medicinal plants like kacholam, arrowroot, moovila, oorila are useful as intercrops in coconut giving enhanced economic returns.

Coconut based mixed farming system comprising of coconut, grass, dairy, poultry, sericulture & pisciculture was found to give better economic returns per unit area. The total variable cost involved in maintaining the above system was Rs.1,56,617. The average net return obtained for a period of four years was Rs.85,824/annum.

The cropping system involving arecanut, cocoa, clove, banana, pepper and coffee could produce about 9.0 t of recyclable biomass/year. The soil nutrient status was higher when the biomass was recycled with 2/3rd of the recommended chemical fertilizer.

Feasibility of intercropping of flower crops like marigold, gladiolus, chrysanthemum and vegetables like radish, cauliflower, cabbage and brinjal in arecanut garden in North-East regions has been successfully demonstrated. In the studies on arecanut based HDMSCS under North Bengal sub Himalayan Terai region, 5 models were developed. It was observed that Model I – Arecanut + black pepper + banana and model – II consisting of Model I+ acid lime provided maximum returns per hectare area.

Under Lakshadweep conditions, intercropping of coconut with maize,sorghum, banana, red gram, betel vine and vegetables like tomato, cucumber, cauliflower, cabbage, chillies and brinjal have been successfully demonstrated. Vermicomposting using coconut leaf wastes have also been demonstrated to localites.

For management of root (wilt) affected coconut palms, an integrated approach has been developed involving application of organic manures like farm yard manure/ green leaf manure/ composted coir pith/ vermicompost at the rate of 25 kg/palm, nitrogen, phosphorus and potassium application @ 500 g: 300 g : 1000 g through application of 1.1 kg urea, 1.5 kg mussorie rock phosphate and 1.7 kg of muriate of potash on per palm, addition of Mg at the rate of 3.0 kg magnesium sulphate (500g MgO) per adult palms, growing of green manure crops like cowpea, or mimosa (*Mimosa invisa*), or calapo, kudzu in coconut basin. Growing compatible intercrops like cassava, elephant foot yam, nutmeg, pepper, banana could increase the productivity of the palms.

Cocoa dry bean yield was highest at 20 l/water/day/tree combined with a fertilizer application of 100:40:140 g NPK/tree/year. Stress effects were visible at water application lower than 20 litres. Net photosynthesis was higher at 1½ level of irrigation and 100:40:140 g NPK/tree/year.

Development of linear spectral reflectance model for identification of root (wilt) disease affected coconut palms using remote sensing and GIS is being attempted. Sub-classification of pixel into proportion of Coconut, Road, Laterite outcrops, Constructions, Arecanut, Others and cloud gave improved the classification accuracy from 75 % to 87%.

Agriculturally Important Micro organisms and organic recycling

Associative N_2–fixing bacteria like *Arthrobacter sp*, *Azoarcus sp* Burkholderia, Bacillus and *Azospirillum amazonense* and *Herbaspirillum* sp belonging to â-subclass of proteobacteria from root regions of coconut have been isolated.

A large-scale inoculation trial in polybag coconut seedlings was conducted using biofertilizers prepared from these diazotrophs. It was observed to increase the root volume, number of healthy roots, secondary roots, collar girth, total dry weight and overall health of the seedlings. Adoption of this technology could produce healthy and vigorous seedlings.

A low cost technology for large-scale production of vermicompost from coconut plantation wastes has been standardised using large pigmented and active local epigeic earthworm identified as *Eudrilus* sp. In 75 days, the whole pre-cured coconut/arecanut palm wastes except the midrib of the leaves can be converted into odourless granular pure vermicastings having C/N ratio of 9.95 and N content of 1.8%N, 0.2% P and 0.16% K. About 70% recovery is obtained in the vermicomposting. Vermicompost prepared from coconut wastes and coir pith was found to be an ideal carrier material to prepare biofertilizers of nitrogen fixing *Beijerinackia indica* and phosphate solubilizing bacteria.

Oyster mushroom *Pleurotus eous* and *P. ostreatus* could be cultivated with higher biological efficiency in coir pith with fermentation technique, coconut bunch waste + paddy straw (1:1). Milky white mushroom *Calocybe indica* was successfully cultivated using fermented coir pith.

A large-scale production technology for producing coir-pith compost has been standardized using the microbial inoculant of *Marasmiellus troyanus*, *Pleurotus florida*, *Trichoderma* sp and a newly isolated fungus. Compost with C:N ratio of 17-18:1 was obtained through this technology.

Technology of vermicomposting of arecanut and cocoa leaf waste with *Eudrilus sp* have been standardised and demonstrated.

4.4. Disease Management

Phytoplasmas from root (wilt) disease affected coconut palms, yellow leaf disease (YLD) affected arecanut palms and spear rot diseased oil palms were purified by double percoll gradient method. Methods for separation of protein components from purified phytoplasma and for extraction of DNA from different tissues of root (wilt) affected palms were standardised. The purity of DNA was determined by agarose gel electrophoresis.

Phytoplasma of coconut root (wilt) disease was consistently amplified using primer pair of P4/P7 to the amplification products of 0.5-0.6 kb. The same primer pair also amplified the target sequence of phytoplasma of YLD of arecanut and spear rot of oil palm.

A rapid and sensitive diagnostic test viz., DAC – Indirect ELISA was standardized for the early detection of root (wilt) disease.

In the breeding for resistance to root (wilt) disease, out of 4247 coconut seedlings produced from different cross combinations (self/*inter se*- WCT, CGD and COD, WCT x CGD and CGD x WCT) by artificial pollination, 2002 seedlings were used for planting/replanting in five seed gardens and 2245 seedlings were distributed to farmers in the disease endemic areas.

The integrated management of root (wilt) disease of coconut was demonstrated in 25-hectare area consisting of 209 farmers plots. With the adoption of technology for leaf rot management the incidence was reduced to 1.5% from 47.9% during pre-demonstration period.

Genomic DNA extracted from 10 isolates of *C. gloeosporioides* and seven isolates of *E. rostratum* and subsequently PCR amplified internal transcribed spacer regions of *C. gloeosporioides* and *E. rostratum* (digesting with nine endonucleases) showed banding pattern corresponding to two groups in *E. rostratum* and three groups in *C. gloeosporioides*.

Based on the surveys conducted to locate YLD free elite arecanut palms in hot spots, 25 palms (24 second generation disease free elite palms in Ernakulam district and one palm in Thrissur district) were identified as field tolerant elite palms.

In the biocontrol studies on coconut bud rot endophytic antagonistic bacterial strain, *Bacillus amyloliquefaciens*, was isolated from the coconut seedlings planted at CPCRI campus. *B. amyloliquefaciens* inhibited the growth of *Phytophthora palmivora* isolates up to 75%.

In case of stem bleeding of coconut, four promising antagonistic fungi *viz*; *T. virens*, *T. harzianum*, *T. viride* and *T. hamatum* were isolated from healthy and diseased palms. An isolate of *T. virens* from healthy palms showed 100% inhibition of *Thelaviopsis paradoxa*.

Phytophthora meadii was isolated from fruit rot and bud rot affected samples of arecanut. In the *in vitro* dual culture studies, *A. terreus*, *M. verrucaria*, *T. harzianum* and *T. viride* were found antagonistic to *P. meadii*.

Among the 20 plant extracts tested *in vitro*, the extracts of henna (*Lawsonia inermis* L.), sacred basil (*Ocimum sanctum* L.), kiriath (*Andrographis paniculata, Nees*), asoka tree (*Polyalthia longifolia* B&H) and blue gum tree (*Eucalyptus globulus* Labill) were found effective in checking the growth of *P.meadii*.

The data of the field trial indicated that stem injection with akomin @3.36 and 5.6 ml followed by root feeding and stem injection with calixin @4.2 ml per palm per application were promising in controlling *Phytopthora* diseases of arecanut as evidenced by less number of nuts affected by fruit rot.

Molecular database for rapid identification of *Phytophthora* were developed. Based on the molecular studies *P. heveae* causing fruit rot of arecanut for the first time have been recorded. *P. meadii* causing immature nut fall of coconut for the first time. *P. arecae* is not a valid species based on AFLP and ITS RFLP. Host specific AFLP groups within *P.capsici* have been identified.

The visible symptoms of the cocoa wilt disease are yellowing or browning of the leaves, wilting of branches and finally death of whole plant. The cocoa wilt disease was invariably associated with infestation by *Xylesandrus compactus*, *X. crassiusulus* beetles and *Ceratocystis* sp.

4.5. Pest Management

In the year 1998 CPCRI first identified and reported the occurrence of the coconut infesting eriophyid mite, *Aceria guerreronis*. This report was the first for the whole of Asia. Palms receiving root feeding of 10 ml Neemazal + 10 ml water and palms base drenched with 10 ml Neemazal along with soil application of Neemcake showed the highest percentage reduction in the eriophyid mite infestation. Continuous studies on incidence of the eriophyid mite showed a declining trend in the incidence of the pest and an increase in the incidence of the predatory mites. Percentage reduction in copra in fully infested nut was 57 % when compared to healthy nuts. However, based on an indexing method, using 0-4 scale it was observed that nuts with 0-3 index do not differ with regard to the fresh weight of nut, weight of husk, weight of fresh kernel and weight of shell and weight of copra.

Studies on the seasonal fluctuations of microbial pathogens of rhinoceros beetle revealed that on an average 5% grubs and 22% adults show infection by OBV. Shade dried leaf powder of the common weed plant *Clerodendron infortunatum* proved its insecticidal property against *Oryctes rhinoceros* at 5% w/w. Incorporation of the whole plant in the breeding sites of rhinoceros beetle proved to be effective in checking the build up of the pest in the breeding sites. Application of naphthalene balls @ 10-12 g/ palm or phorate 10 G @5 g/palm or leaf axil filling of powdered marotti cake (*Hydnocarpus*) @250g/palm during May, September and January proved to be effective as a prophylactic control measure for rhinoceros beetle and red weevil.

Demonstration of *Oryctes* IPM utilizing the microbial control agents viz., Baculovirus and M*etarhizium anisopliae* showed that there was 66 per cent reduction in leaf damage, 95.4 per cent reduction in spindle damage and 62.5 per cent reduction in spathe damage after the implementation of the project.

A mass multiplication technique was standardized for the early instar parasitoid, *Apanteles taragamae*, of coconut leaf eating caterpillar, *Opisina arenosella* . *Goniozus nephantidis* , the larval parasitoid has been found to be temperature tolerant that can survive various temperature ranges and *Elasmus nephantidis*, the pre-pupal parasitoid showed temperature specificity.*Goniozus nephantidis* and *Elasmus nephantidis* showed high fecundity and produced maximum progeny/host larva and higher number of females on *Opisina* larvae reared on Chowghat Green Dwarf (CGD).

Preliminary surveys on entomophilic nematodes revealed presence of *Heterorhabditis* as a major entomopathogenic nematode (EPN) in the coconut ecosystem.

Detailed studies on biology and bionomics of coreid bug, which has emerged as a potential pest of coconut in Southern Kerala revealed that for an effective management of the pest three rounds of pesticide application using 0.1% carbaryl is required.

Ferrugineol , the aggregation pheromone of red weevil was synthesized at CPCRI in collaboration with CRI, Sri Lanka. Field studies have indicated the effectiveness of the pheromone in attracting red weevils. Addition of phagostimulants is essential for increasing the efficacy of pheromone trap. Locally available materials like banana and pineapple were found to be ideal phagostimulants for use in the pheromone traps.

An egg parasite of the pentatomid bug, *Halyomorpha marmorea* which causes immature fruit drop in areca palm is identified as the eupelmid, *Anastatus bangalorensis.*

One of these, a predator of the cocoa mealy bug, *Planococcus lilacinus*, was got identified through the services of Natural History Museum, London as *Triommata coccidivora* (Felt).

The predominant scale insects collected from areca palms were got identified as the oriental scale, *Aonidiella orientalis*, the mussel scale *Lepidosaphes karcarica* and the pandanus scale, *Pinnaspis buxi* (Bouche). All these scales infest the leaves and developing fruit bunches.

4.6. Plant Physiology and Biochemistry

The drought tolerant nature of WCT x WCT, FMS, PHOT and WCT x COD and the drought susceptible nature of COD x WCT, COD and GBGD are further confirmed by their anatomical features. The differential response of the seedlings during stress condition in terms of chlorophyll fluorescence characteristics and Hill activity indicated that photosystem II is affected during stress more in WCT and MYD than in FMS and CGD. The genetic analysis of stress responsive characters revealed that leaf water potential was the most useful parameter under genetic control.

Spraying salicylic acid had given encouraging results in arresting coconut button shedding. The studies have clearly indicated that coconut regulate the female flower production and shedding of buttons through the operation of a steady carbon –nitrogen metabolism which in turn is regulated by the environmental variables.

Coconut cultivars and hybrids viz., West Coast Tall (WCT), Chandra kalpa (LCT), Pratap (Benaulim), Kera ganga (WCT x GBGD), Chandra sankara (COD x WCT), Laksha ganga (LCT x GBGD) and Chandra laksha (LCT x COD) were evaluated based on gas exchange characteristics, enzymes of carbon and nitrogen metabolism, leaf traits , dry matter production and yield to identify the superior cultivar among the released ones. Photosynthetic characteristics showed higher photosynthetic efficiency in hybrids where as talls recorded higher WUE.

Among the cultivars and hybrids the performance of Keraganga and Lakshaganga was found to be better than the others in terms of leaf traits, dry matter production and yield. COD x WCT had higher levels of carbohydrates and proteins in the kernel, though it also had more longer chain fatty acids, to its disadvantage. Other promising hybrids are WCT x GBGD for its higher carbohydrate content and LCT x GBGD for its higher protein content.

The oil content (%) varied from 64 to 70 % among the cultivars. LCT, LCT x GBGD had highest oil concentration while FMST had the lowest oil content. From the study it can be assessed that the oil from hybrids is better suited for human consumption. Oil from ADOT, LCT, LCT x GBD and LCT X COD, which had high lauric acid content, is better suited for industrial purposes.

Characterization of drought in different coconut growing areas and drought management strategies were undertaken in different agro-climatic zones viz., Western coastal area – hot sub-humid-per-humid (Kasaragod – Kerala; Ratnagiri – Maharastra), hot semi- arid (Arisikere – Karnataka) and Eastern coastal plains- hot sub-humid (Veppankulum- Tamil Nadu; Ambajipeta- Andhra Pradesh), which represent the major coconut growing areas in India.

Weather based models for prediction of nut yield were developed. Field drought tolerant palms were identified *in situ* during surveys conducted in farmers' plots under rainfed condition at Arsikere, Ambajipeta and Ratnagiri. Soil moisture conservation treatments recommended are burial of coconut husk in the basin; or mulching palm basins with dry coconut leaves or burial of composted coir pith. These treatments are effective to improve soil moisture conservation and increase coconut yield.

Studies have been initiated to observe the changes in stress responsive proteins in coconut using SDS-PAGE / 2D electrophoresis protocol. Presence of 17 Kda band was noted in the temperature induced and in flooded seedling leaflet tissue, while a 30 Kda band was noticed in temperature induced root tissue.

In an experiment to determine the effects of pruning and trailing of cocoa in the interspaces of arecanut, it was observed that the treatments with the spacing of 2.7x2.7 m and 2.7x5.4 m and large canopy size increased the bean yield significantly. Correlations were done between yield and canopy characters which showed positive relationship with canopy area and leaf area.

In the project to evaluate drought tolerance in cocoa crossing work involving high yielding and drought tolerant parent trees was undertaken. Drought tolerance is shown to be inherited among 1-21 x NC 42/94 and 1-29 x NC 23/43 cocoa clones.

4.7. Value-Addition and Post Harvest Technology

A solar cum electrical drier with agriculture waste as third source of energy has been fabricated for drying 2000 cups of coconut for copra making. The time taken for drying 2000 cups was around 22-24 hrs only. The construction cost of the dryer was estimated to be Rs. 40000/= and expected life of the dryer was 10 years. The cost of drying was calculated as Rs.1.05 / kg of copra when heaters are used and 88 paise / kg of copra when only solar energy is used.

A model agro- processing centre to study its techno – economic feasibility consisting of an oil expeller, filter press and copra cutter was installed at the Institute.

A user friendly snowball tender nut machine has been developed at CPCRI. This machine is used for preparation of snowball tender coconut (SBTN), which is a nutritive drink and its tender kernel can be consumed as a snack at the same time. This is one of the diversified coconut product developed at CPCRI, which is being popularized as welcome drink to tourists.

The physical, chemical and thermal characteristics of the shell and husk of tender coconut of 8 month maturity have been studied and a process has been developed for the production of fuel briquette from the tender coconut husk and shell. Besides these, attempts have been made to degrade coconut husk using bio-polymer degrading microorganisms.

Methodologies have been standardized for production of intermediate moisture coconut kernel by using sugar syrup and salt brine. The different ratio between osmotic medium to kernel were studied and found that the ratio of 4:1 (osmotic medium to kernel) was optimum for the osmotic dehydration of coconut.

CPCRI has successfully developed a technology for production of sweet coconut chips, flavoured coconut chips, medicated and spicy coconut chips. This technology has been transferred to many small-scale entrepreneurs in Kerala and Tamil Nadu. Modified atmosphere packaging of fresh kernel, edible copra, coconut chips and coconut paste using different films of various thickness, different preservatives and its combinations, different mixing ratio of gas O_2, CO_2 and N_2 have been standardized to market the products in quality conditions. This technology has also been utilised to package turmeric powder produced from IISR, Calicut.

A pilot scale fluidised bed drier has been fabricated for drying disintegrated fresh coconut kernel with a capacity to accommodate 200 coconuts per batch. Biogas production using coir pith: cow-dung at 1:4 ratio has been found to give adequate supply of methane gas at 33 ^{0}C.

To utilize coir-pith as fluid fuel, CPCRI has designed and developed furnace to burn coconut pith in suspension. A palm oil extraction unit has been designed and installed at NRCOP, RC, Palode (erstwhile

RC, CPCRI), fabricated a 1000 nut capacity smoke free copra drier, designed a power operated sprayer for tall plantation palms with a telescopic pipe assembly capable of reaching 42 feet height. A coconut-splitting machine was also fabricated at the Technology section.

Amla Pan: A supari formulation consisting of arecanut, dried gooseberry, dried nuts (badam, pista, cashew nuts), soya beans and raisins have been standardized. Besides this the wound healing properties, antimicrobial properties and carcinogenic character of the arecanut have also been evaluated**.**

4.8. Transfer of Technology

With the aim to extend the production, protection, processing and post harvest technologies developed at CPCRI in coconut, arecanut and cocoa, scheduled training programmes, special training programmes and training to foreign nationals were regularly conducted at CPCRI and its Regional Stations/Centres.

CPCRI introduced the Interface programmes concept, which were organized in 11 district headquarters to highlight the viable technologies related to production, protection and post harvest processing of coconut evolved at CPCRI and to discuss the scope as well as constraints in the adoption of technologies in farmers' fields for improving the coconut scenario in Kerala Sate. The programme was organized in collaboration with the Department of Agriculture, Kerala Agricultural University and Coconut Development Board.

In the Front Line Demonstration of technologies, plots were maintained in farmers' gardens on selected technologies to prove the technical feasibility and economic viability of the technologies. FLD plots were maintained on coconut based high density multi species cropping systems at CPCRI, Kasaragod, on Integrated management of root (wilt) affected coconut gardens at CPCRI RS, Kayangulam and on Arecanut based cropping systems at CPCRI RC, Mohitnagar.

Video films and audio cassettes on the important technologies were produced as a part of TOT activities. A total of 85 radio talk/programmes were presented by the scientists of the institute, through the stations of All India Radio, (Kannur, Calicut, Trivandrum, Allappuzha & Mangalore) on topics related to the production, protection and processing of coconut, arecanut and cocoa, during the last five years.

A total of 280 popular articles were published by the scientists of the institute, in various farm journals/ newspapers on topics related to the production, protection and processing of coconut, arecanut and cocoa. About 74 extension publications covering all the viable technologies developed at CPCRI were published during the period.

Farm Advisory Service through several postal queries, telephone enquiries and e-mail queries from farmers relating to various aspects of production, protection and processing aspects of palms and cocoa were replied during the period.

In a study on adoption of package of practices by the coconut cultivators of Kannur district only 14 per cent of the farmers cultivated coconut hybrids, 39 per cent of the gardens maintained proper spacing between coconut palms, 34 per cent of the cultivators followed basin irrigation method and only 28 per cent of the farmers applied chemical fertilizers. Crop protection practices were very low. However, more than 40 % of the farmers practiced coconut based farming systems.

Knowledge and Adoption levels of recommended technologies by the arecanut farmers of Karnataka were low as majority of the farmers (41%) belonged to low level of knowledge and low level of adoption (85%).

A Participatory technology transfer (PTT) programme on integrated root (wilt) management technologies revealed significant impact on awareness, knowledge and adoption of technologies.

Documentation of the items of indigenous technical knowledge in coconut and arecanut cultivation was completed and a publication entitled " Indigenous technical knowledge in coconut and arecanut cultivation" was brought out. The results of the survey done in the IPGRI/DFID Project on Coconut based poverty reduction programme – Phase I, was published as book entitled "Coconut Community in India - A Profile". Based on the survey, two new projects to be sponsored by ADB and IFAD are being sanctioned.

The IPGRI – COGENT sponsored project on " Developing sustainable coconut based income generating technologies in poor rural communities in India" aims at implementing appropriate coconut based technological interventions in selected coconut communities to reduce poverty with the basic assumption that "small coconut farmers need not remain poor always". Two coconut communities were selected to implement the project; viz, Pallikkara in Kasaragod District (representing West Coast region) and Ariyankuppam in Pondicherry State (representing east coast region).

4.9. Production economics and marketing aspects

The global trend in area, production and productivity of coconut in India indicated that all the three parameters had exhibited increasing trend except in Malaysia. In India, the respective CGR (%) for area and production are 1.87 and 1.68 and for productivity it is -0.19.

The secondary data on area, production and productivity of arecanut exhibited an increasing trend for the period 1967-68 to 1997-98. Simple growth rates indicated that during seventies the area had decreased, but the same had increased since eighties. However the production had increased through out the reference period 1997-2002.

The Compound Growth Rate of area under cocoa was 43.5 % during late seventies to mid eighties 1975-85, the same had shown negative growth rate (-5.9 %) in late eighties to early nineties. From mid nineties, the growth rate was positive with 5.68 %. The respective CGR for production was 55.7 %, -2.65 % and 10.08 %.

The forecasted demand for coconut and its products using secondary data from 1970-71 to 2000-01, based on linear model $Y = a + b(t)$ is 20572 million nuts, 1152 ('00 MT) and 691 ('00 MT) of coconut, copra and coconut oil respectively. The same using exponential model $Y = a b^t$ is 21941 million nuts, 1241 ('00 MT) and 745 ('00 MT) respectively.

The forecasted demand for arecanut using secondary data from 1955-56 to 1998-99, fitting quadratic function $Y = a + b(t) + c(t^2)$ was 0.34 million tones for the period 2005-06 and the same for 2010-11 was 0.36 million tones.

Investment analysis for manufacturing value added coconut products proved the economic worthiness of producing products like desiccated coconut, coconut oil, coconut shell charcoal, coconut based vinegar, coconut chips, Snow Ball Tender Nut.

Price spread analysis of arecanut indicated that 80 % of the farmers dispose their produce immediately and the channel consisting of Producer- co-operative society - co-operative society's sales depot (consuming center) - retailer - panwalah – consumer was the most efficient with the lowest compost index score of 1.5.

Economic analysis of arecanut based farming systems, of plantation crops, and of palm based farming systems has clearly indicated that intercultivation of vegetable, flowers, spices, tubers along with animal husbandry was more profitable than monocrop farming.

4.10. Information technology

The CPCRI web site (http://www.cpcri.nic.in): The CPCRI website was developed and hosted under NIC Server on 10th April, 2000. Continuous updating of the information and also modification of pages were carried out. The website includes CPCRI history, organization structure, achievements of various Divisions and centres, future thrust, personnel, transfer of technology, training programmes and AICRP Palms. It provides latest research and development information with reference to our mandate crops. A new facility for the farmers for online registration of their planting material requirement was added to the web site facility as a step for strengthening the activities under ATIC. Padmavibhushan Dr M. S. Swaminathan inaugurated the online registration service on 8th February 2002.

Software has been developed to maintain and retrieve data on different resources of CPCRI like land, buildings and other infrastructure like equipments, vehicles, human resources etc.

Computerization of Institute activities: Accounts format was created and shared. This is available in the network and is actively utilized at the main campus. Project database of CPCRI was developed. Weather data of CPCRI Regional Station, Vittal for the year 2001 has been computerized and the weather data package has been modified for Y2K compliance.

Expert system on coconut pests and disease management is being developed. Parallel processing for large-scale data analysis using the algorithm was prepared in Single Instruction Stream, Multiple Data Stream model.

Several CD-ROMS on different topics have been created for spreading the technology to end-users.

4.11. Agricultural statistics

A pilot sample survey was conducted in Alappuzha district to understand the extent of losses incurred by the farmers due to eriophyid mite and also to evolve a suitable procedure of estimation of crop loss. By adopting the regression estimates as employed in double sampling, the per cent incidence of mite in the district was worked out to be 82.4% of the bearing palms.

A Pilot Study on the Estimation of Cost of Production of Coconut in Kerala was conducted in collaboration with Indian Agricultural Statistics Research Institute, New Delhi during the year 2001. The salient findings of the study are given below:

i) The bearing stage accounted for more than 75% of the total number of palms. Palm density was high in smallholdings. Replanting/under planting was observed to be minimum in large holdings (3 to 6 seedlings/ha).

ii) Incidence of bud rot disease and infestation by red palm weevil were the major reasons for the loss of palms.

iii) Overall, one fourth of the nuts harvested in the holding were utilized for culinary purposes; 40 to 50 % nuts were sold; 4 to 21% nuts harvested were utilized for making copra. Less than 5% nuts only harvested as tender nuts.

iv) The farm gate price varied from Rs.2.31 to 3.2.

In the Integrated National Agricultural Resources Information System (INARIS) which was initiated in the year 2001, CPCRI centre was first to conduct the requirement analysis workshop during June 28-30, 2001 on Agro techniques, Statistics and Research on plantation crops. Besides achieving many other targets in short period it has compiled crop statistics data and populated in the database in MS Access.

Statistical Investigations for improving Research Methodology in Plantation crops have been developed through use of non-parametric data analysis and analysis of data using risk transformation methods.

Using statistical analyses fertiliser response studies in different coconut growing zones at Veppankulam, Ambajipet, Konark and Aliyarnagar were undertaken. Elimination of positional effect was also analysed.

4.12. Agricultural Technology Information Centre

ICAR sanctioned a project entitled "Establishment of Agricultural Technology Information Centre (ATIC)" during Phase II under NATP for implementation at CPCRI, Kasaragod during 1999-2003 with a total budgetary provision for Rs. 42.575 lakhs.

The Centre started offering the following services from 2nd February, 2000. Guidance on technologies available at CPCRI; Farm literature – Priced and free publications; Video show (for farmers and development personnel visiting the ATIC); Mini exhibition; Expert electronic information package – in the form of CD ROM on coconut, arecanut and cocoa cultivation; Soil and water sample analysis; Planting materials for coconut and arecanut; Earth worm for vermicomposting; vermicompost; mushroom Spawn and Farm products – Coconut and tender coconut.

The popularity of CPCRI among the stakeholders has gone up tremendously. Due to heavy demand from visitors, most of the priced publications at CPCRI were exhausted and printing of a number of Bulletins (priced publications) is in progress. Our web site is well visited by users. Approximately, 15000 members are visiting our web site per annum.

Honours/ Awards/ Recognitions

The CPCRI and its staff have been recipients of national awards and have been recognized for their performance in different fields. Few important ones are Sardar Patel Outstanding ICAR Institution Award for 2002, Best K.V.K. Award for 2002-03, two outstanding team research awards and six individual awards.

5. IMPACT ASSESSMENT

5.1. Growth

The trend in growth of area, production and productivity of the mandate crops viz., coconut, arecanut and cocoa were analyzed using Compound Growth Rate techniques and the details are furnished below.

Coconut

The Compound Growth Rate analysis of area under coconut indicated that during the period 1960-70 there was significant increase in area (4.1%) and the same trend was repeated for the period 1980-90 (3.47%) and 1990-03 (2.0%).The overall CGR (%) for area under coconut for the period 1960-2003 was 2.24%. In the case of production, there was significant increasing trend for the periods 1960-70 (2.60%), 1980-90 (4.69%) and 1960-2003 (2.73%). The increase in productivity was significant during the period 1980-90 (1.19%) and the same for the overall period 1960-2003 was 0.49%.

Arecanut

The Compound Growth Rate of area, production and productivity of arecanut for the period 1983-84 to 2002-03 was 3.00 %, 2.82 % and 0.41 % indicating that area effect on production is more than that of productivity effect.

Cocoa

The Compound Growth Rate of area, and production of cocoa for the period 1972-2002 was -0.95 % and 11.56 % indicating that productivity effect on production was higher than the area effect.

5.2. Input Output Assessment

Traditionally the agricultural researchers, having a good idea of the constraints pertaining to their field of specialization use them for research problem definition. By this, they often fail to observe that any change caused by the introduction of a new technology will not only affect the component being studied, but the entire farming system within which the component is embedded. Agricultural research in India, often aims to increase the productivity of crops without paying much attention to the economic viability of those technologies under farmer's field condition. In contrast, farmers are more interested in raising profits, which need not be necessarily through increase in productivity. Hence for better adoption of research results by the farmers, in addition to productivity, more attention is required on the socio-economic aspects of the evolved technologies. To summarize, for increasing the rate of adoption of various technologies, their technical feasibility, economic viability and social acceptability needs to be proved under farmer's field conditions.

It is expected that through increased adoption of these technologies, farmers and processors would be able to increase the productivity and returns from their ventures in cultivation and processing of coconut, arecanut and cocoa in the country. In addition to the technical feasibility, the economic viability of the technologies in terms of rates of return is very much essential for technology adoption. The following technologies may be considered as the utility of the research outcome to farmers and other end users. These technologies are listed below along with their Rate of Returns.

Sl.No.	Technology	Rate of Return (%)
	COCONUT	
01	High yielding coconut varieties	27.25
02	Coconut hybrids	28.87
03	Replanting or under-planting	20.15
04	Integrated nutrient management	19.52
05	Irrigation methods	18.25
06	Inter cultivation	19.85
07	Green manuring	19.89
08	Vermi-composting	27.25
09	Mushroom cultivation through recycling waste products	28.52
10	Coconut based cropping systems	25.25 to 37.89
11	Coconut based mixed farming	35.25
12	Drought management techniques	24.38
13	Integrated Pest Management	18.78
14	Integrated Disease Management	23.75
15	Post Harvest Technologies and Value Addition	16.75 to 29.00
	ARECANUT	
16	High yielding arecanut varieties	22.85
17	Crop management practices	27.35
18	Integrated Nutrient Management	29.16
19	Irrigation Management	39.89
20	Arecanut Based Cropping Systems	32.33
21	Arecanut Waste Utilization	22.58
	COCOA	
22	High Yielding Cocoa Accessions	21.75
23	Pruning and canopy management techniques	25.78
24	Pest management in cocoa	29.55
25	Disease management in cocoa	18.75

5.3. Gaps and Shortcomings

Yield gap analysis

Macro level yield gap analysis of the three mandate crops indicated that there is wider scope for technology adoption for further improving the average productivity. The difference between the average yield under farmer's field conditions and the yield achieved under research station conditions (Yield Gap 1) for coconut was 122.22 %. The same in the case of arecanut and cocoa was respectively 144.66 percent and 100 percent. The difference between the farmer's yield and the potential yield that could be achieved in coconut (Yield Gap 2) was 400 percent. The same in the case of arecanut and cocoa was 36.24 and 25 percent respectively.

Gap analysis

Sl.No.	Particulars	Value
01	**Coconut (Predominantly cultivated variety)**	
	Potential per palm yield (nuts/palm)	400
	Research Station yield (nuts/palm)	80
	Farmer's field yield (nuts/palm)	36
	Yield Gap 1 (%)	122.22
	Yield Gap 2 (%)	400
02	**Arecanut (Predominantly cultivated variety)**	
	Potential per palm yield in chali (kg /palm)	5.00
	Research Station yield in chali (kg/palm)	3.67
	Farmer's field yield in chali (kg/palm)	1.50
	Yield Gap 1 (%)	144.66
	Yield Gap 2 (%)	36.24
03	**Cocoa (Predominantly cultivated Accession)**	
	Potential per tree yield as dry beans (kg /tree)	1.00
	Research Station yield as dry beans (kg/tree)	0.80
	Farmer's field yield as dry beans (kg/tree)	0.40
	Yield Gap 1 (%)	100
	Yield Gap 2 (%)	25

Shortcomings

- Whether, willing or not, having become a member of WTO, India needs to tackle the issues arising out of World Trade Agreement on Agriculture.
- Plant Variety Protection (PVP) is a very important issue under WTO.
- Plantation Crops farmers cannot adjust to the short and medium run demands of WTA.
- Non implementation of technology prioritizing for achieving sustainable growth.
- Poor rate of technology adoption.
- Adoption of technology as a single component.

5.4. Lessons learnt, suggestions and options for future

Lessons learnt and suggestions

General

- CPCRI technologies could be adopted if adequate support is given by the Development Departments
- Small and marginal holdings does not realize the economies of scale of production
- The benefits of CPCRI research should reach farmers from other major producing states such as Andhra Pradesh, Karnataka, Tamil Nadu, Pondicherry, Maharashtra, Goa etc.
- Location specific technologies are required and general recommendations are of less importance
- In various production zones, there are several structural constraints which hinders technology adoption and unless these constraints are removed, technology adoption could not be possible to the desired level

Coconut

- Supply of elite planting materials are too shorter than their demand in all the major coconut producing states
- Drought is a major problem in Tamil Nadu and parts of Kerala and Karnataka. Drought management practices needs to be extended on a larger scale in these states through proper coordination between CPCRI and the State Department of Agriculture
- Eriophyid mite continues to be a serious pest in all the major coconut producing states. The management strategies needs to be refined considering the cost-economics of the technology
- Management of root (wilt) disease should receive prime attention in Southern Kerala
- Specific development schemes are needed on coconut based cropping / farming systems
- Integrated Pest and Disease Management measures needs to be cost effective
- Integrated Crop Management should be the prime goal of the research institutes rather than separating them based on disciplines
- Economics of technologies should be considered as the most important factor for technology adoption
- Post Harvest Technologies are not economically viable on a smaller scale
- Assured market with price stability for coconut and its products is required in the long run

Arecanut

- Supply of elite planting materials are too shorter than their demand in the major arecanut producing states
- Specific development schemes are needed on arecanut based cropping / farming systems
- Assured price with better stability is required for arecanut and its products
- Management of Yellow Leaf Disease should receive prime attention among the researchers
- Arecanut plantations in drought prone districts needs special care with reference to water management practices
- Harvesting and spraying operations in arecanut is not economically viable. Hence breeding for dwarf varieties needs additional emphasis by the researchers

Cocoa

- Assured price with better stability is required for cocoa and its products
- Co-operative way of dealing private chocolate manufacturers with regard to cocoa cultivation and marketing
- Integrated management practices for improving cocoa productivity
- Effective and economical way of tackling black pod disease and cocoa wilt disease.

Options for Future

- A separate wing of WTO cell may function in all the ICAR institutes and SAU's and they need to prioritize the issues arising out of WTO and suggests ways and means to tackle them. This Cell should function on Mission Mode basis. The Director/Director of Research/Vice-Chancellor should lead this cell.
- The WTO Cell in various ICAR / SAU's may deal PVP issue taking the same on most urgent basis.
- Both the Ministry of Commerce and Agriculture may consider the possibilities of minimizing the deleterious effects of WTA to plantation crop farmers
- The major goal in planning for achieving sustainable productivity in all the major field and horticultural crops is to classify the existing production zones as high, medium and low. Then three different research and development strategies need to be planned and implemented for these zones. The focus is to strike the crux of the problem, which hinders to bring the low productive zone to a medium or high productive zone, the medium productive zone to high productive zone and to sustain the level of productivity in high productive zone.
- Technology adoption is low to medium (except in few parts of the country). If we sub-classify the constraints for non-adoption of the technologies, the major reasons would focus on structural problems such as small holding size, lack of infrastructures such as irrigation facilities, capital/credit facilities etc.
- Experience indicates that rural poverty cannot be reduced through a single/minimum number of technology interventions. For realizing significant increase in the income level of rural poor, all the possible avenues need to be explored. Multiple technologies not only in crops but also in allied enterprises may be identified and implemented.

6. SCENARIO AND SWOT ANALYSIS

6.1. Global scenario

Coconut is grown in an area of 12.19 million ha producing 61.165 billion nuts or 13.68 million tonnes of copra equivalent in more than 93 countries, of which Asia and Pacific regions occupy 10.4 million ha (87.9%) and producing 8.9 million tonnes of copra. Indonesia, Philippines and India are the major producers of coconut in the world. During the period 1980 to 2003, the global area, production and productivity have exhibited an increasing trend. The global area under coconut which was 87 lakh ha during 1980, had increased to 106 lakh ha (21.8%). During the same period, the production on dry copra equivalent basis has increased from 32.2 million tonnes to 52.9 million tonnes (64.3%) and productivity had increased from 3675 kg/ha to 4986 kg/ha (35.67%). The area, production and productivity in Indonesia are 26.75 lakh ha, 15.63 million tonnes and 5842 kg/ha respectively. The respective figures for the Philippines are 31.40 lakh ha, 13.7 million tonnes and 4363 kg/ha. During the same period, the index numbers of area under coconut had increased by 68 % in India, 48% in Indonesia, 44% in Thailand, 98% in Vietnam and 5% in Solomon Islands. The same had declined by 50% in Samoa, 48% in Malaysia, 11% in Papua New Guinea, 10% in Fiji Islands, 3% in the Philippines and 2% in Sri Lanka.

During the period 1980 to 2003, the index numbers for coconut production indicated that the production had increased in India, Indonesia, Philippines, Sri Lanka, Solomon Islands, Thailand and Vietnam. The percentage of increase varied from 17.82 in Sri Lanka to 185.71 in the case of Thailand. The same for India was 123.53 percent. However, the same had declined in Papua New Guinea, Samoa, Vanuatu, Fiji Islands and Malaysia. During the same period, the index numbers for coconut productivity indicated that the same had increased by 54% in the Philippines, 54% in Samoa, 49% in Vietnam, 47% in Thailand, 45% in Solomon Islands, 33% in India, 22% in Indonesia and 20% in Malaysia. However, the productivity had decreased by 31% in Vanuatu.

Arecanut palm is a major perennial crop mainly used as a masticatory in South and South East Asia. During the period 1990 to 2003, the index numbers for the world arecanut area has increased by 38.3%. During the same period, respective increase in production and productivity was 47.9% and 6.9%. India is the largest producer of arecanut in the world. Myanmar, Indonesia, Bangladesh, Malaysia and China are the other major producers. During the period 1990 to 2003, in Myanmar, area under arecanut had increased from 24.4% and the production and productivity by 76.9% and 41.1%, respectively. In Indonesia, though the area had decreased by 8.1%, the production and productivity had increased by 63.8% and 94.2%, respectively during the same period.

Cocoa is a major beverage crop grown in Latin American, African and Asian countries. Brazil, Ivory Coast, Malaysia and Ghana are the major cocoa producing countries in the world. During the period 1990 – 2003, the index numbers indicated that the world area, under cocoa had increased by 2.27%, while the production and productivity had increased by 28.6% and 4.9%, respectively. During the same period in Ghana the respective increase in area, production and productivity was 116.3%, 61.9% and 25.3% respectively. However in Brazil, decrease in area, production and productivity was 12.6%, 33.3% and 30.9%, respectively.

Indian scenario

Coconut, arecanut and cocoa are the major small land holder's plantation crops cultivated in India. In terms of agro-climatic conditions, these crops are cultivated predominantly in the humid tropics and tropical belts of the country extending throughout the peninsular India comprising of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, parts of Maharashtra, and the north eastern region. They are cultivated in wide range of soils ranging from sandy, sandy loam, laterite etc. The major socio-economic features in which these crops are cultivated include predominance of small and marginal holdings, medium to resource poor farm environment, less marketable surplus and marketed surplus etc. However, in crops such as coconut and arecanut, India has the highest productivity. Strengthening the strategies for production of diversified value added products from these crops would augment the export, which would in turn improve the domestic production sector. A brief account of the Indian scenario in respect of each one of these crops is attempted below.

Coconut

The country's annual production of coconut is to the tune of 12833 million nuts from an area of 19.35 lakh hectares. The realized average annual productivity of 6632 nuts/ha is the highest in the World. Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the four major coconut producing states accounting for more than 90 per cent of the share in area and production. This only shows that India can attain the premier position in coconut production with some more area expansion and by improving the productivity by adoption of modern technologies of production. Kerala is the largest coconut growing state in the country with an annual production of 5727 million nuts from an area of 8.98 lakh hectares and an average productivity of 6379 nuts/ha. Tamil Nadu is the second largest coconut producing State with an annual production of 3244 million nuts from an area of 3.57 lakh hectares with an average productivity of 9083 nuts/ha. Karnataka is the third largest producer of Coconut in India. The area, production and productivity of coconut in the State are respectively 1210 million nuts, 3.85 lakh hectares and 3139 nuts/ha. The same in the case of Andhra Pradesh is 1199 million nuts, 1.04 lakh hectares and 11532 kg/ha respectively.

In the present scenario, the country leads the world in the production and export of coir products. In addition, India also produces and exports other products such as raw coconut, desiccated coconut powder (D. C. Powder) and coconut oil.

Arecanut

India is the largest producer of arecanut in the world. The area and production of arecanut in India showed an increasing trend during the past 40 years. Karnataka, Kerala, Assam, Tamil Nadu and West Bengal are the important states growing arecanut. The area, production and productivity of arecanut in Karnataka State is 1.49 lakh ha, 1.99 lakh and 1335 kg/ha respectively. The same figures in case of Kerala, the second largest producer are 1.02 lakh ha, 1.05 lakh MT and 1029 kg/ha. The area, production and productivity of arecanut in Assam are 0.74 lakh ha, 0.69 lakh MT and 936 kg/ha. At present India produces 4.39 lakh MT of arecanut from an area of 3.64 lakh ha and the average productivity is 1202 kg/ha of fresh nut. India exports whole betel nut to 22 countries of which Yemen Republic, Bangladesh and UK are the prime importers.

Cocoa

Cocoa is grown as intercrop or more precisely a companion crop under irrigated coconut and arecanut gardens. This beverage crop is cultivated in about 29471 ha and the annual production is about 10,175 MT with a productivity of 530 kg/ha (2005-06). The area, production and productivity for Kerala, the largest producing State of cocoa is 10220 ha, 6490 MT and 770 kg/ha. The same in the case of Karnataka, the second largest producing State is 6000 ha, 2750 MT and 825 kg/ha respectively. India exports cocoa butter, husks and shell, cocoa paste and cocoa powder and cake to many countries. UAE and USA are the major importers of cocoa beans, while the Netherlands, Poland, Kuwait and Egypt are the major importers of cocoa shells and husks. UK is the main importer of cocoa butter fat, while Nepal imports huge quantity of cocoa powder from India. In addition, India also exports chocolate and confectionaries to more than 25 countries to the tune of 579 MT annually. The total foreign earnings from the export of cocoa and its products is Rs.7.58 crores. The trend in the quantity and volume of exports of cocoa and its products exhibits an increasing trend. The Indian chocolate market is about 20,000 tonnes and is growing at about 15 percent per year. The production of cocoa beans hardly meets 30% of the demand projected by the processing industry in India. As assessed, the demand of cocoa beans is 30,000 MT by 2005 AD. The strategies suggested for achieving sustainable growth in cocoa exports are a) increasing the productivity through adoption of production, protection and processing technologies and b) to upgrade the processing technologies in the manufacture of chocolates and confectionery.

Scenario for Coconut: 2025

At present the entire coconut production in the country is consumed domestically. However, the demand for coconut is expected to be increased in the future as tender coconut has gained acceptance through out the country as a healthy and natural drink. The market for tender coconut will be further increased as the country's economy displaying an overall growth rate near to two digits. The long term annual growth rate of supply is only 2.5% , but may not be sustained as no further scope for area expansion and in the traditionally cultivated regions, the production is almost stagnant in the recent decade. The demand for coconut during 2025 will be around 21975 million nuts with a projected production of 15734 million nuts. Therefore the gap in supply and demand is expected to be increased further. The productivity has to be increased in traditionally cultivated areas to meet the increased demand for which the group approach in technology transfer as successfully demonstrated by CPCRI could be taken as a model.

Demand – Supply (Million nuts)

Year	Demand[1]	Supply[2]	Gap
2005	13345	12418	927
2010	15086	13247	1839
2015	17054	14076	2978
2025	21795	15734	6061

[1]Demand is worked out at 2.5% annual growth rate

[2]Supply is based on ARIMA(1,1,0) model

Demand and supply (MT) scenario : Cocoa

Year	Demand[1]	Supply[2]	Gap
2005	14000	8000	6000
2010	22500	13000	9500
2015	36300	20500	15800
2025	72600	41000	31600

[1]Demand is calculated at 10percent annual increase

[2] Supply is calculated at present rate of production expansion

Envisages to double in next 10 years ie.2015-2025

Demand and supply scenario for arecanut

The area under this crop has increased from 94800 (1956-57) to 3.65 lakh ha (2003-04). During the same period the production has grown up form 74700t to 4.39 lakh tones, which is already meeting the targets. However, productivity has become stagnant because of improper input management. The average productivity in India is 1202 kg/ha (2003-04). So the emphasize should be on increasing the productivity and income per unit area.

Demand and supply scenario for cocoa

The Indian chocolate market is about 20,000 tonnes and is growing at about 15 percent per year. The production of cocoa beans hardly meets 30% of the demand projected by the processing industry in India. As assessed, the demand of cocoa beans is 30,000 MT by 2005 AD. The same will be 72600 MT by 2025.

Emerging scenario

Indian population will increase to 1363 million in 2025 at an annual growth rate of 1.2 per cent. In terms of uses of coconuts within India, about 47 per cent could be used for edible purpose or the religious purpose, about 28 per cent for copra about 19 per cent for tender coconut and about 6 per cent for edible copra. That is we may require 10243 million nuts for edible purpose or the religious purpose, 6102 million nuts for copra, 4141 million nuts for tender coconut and about 1308 million nuts for edible copra.

Growth in income, particularly in developing countries is anticipated to lead to an increase in demand for various products. Global Gross Domestic Product (GDP) has increased by nearly 87 per cent over the past 25 years and is predicted to continue rising by 40 per cent by 2010 despite threats of downturn in global economy. The per capita GDP is expected to rise by more than 20 per cent and as per capita income increases so will per capita consumption. Uses of coconut and its products as functional foods, nutriceutical, pharmaceutical and cosmetics as well as bio fuel will likely to increase in the years to come. The use of medium chain fatty acids and the lauric acid in producing antiviral, antifungal, antiprotozoal, and anti microbial medicines, particularly use of lauricidin in the cure of my / AIDS virus will go a long way in creating market potential for coconut oil and virgin coconut oil. The tender nut water as energy drink, nutritional drink, health drink and sports drink has unlimited market potential. The world demand for coir pith is growing at a rate of 15 per cent per annum.

Competing countries for coconut production

Last three decades, India, Indonesia and Philippines had considerably increased the area under coconut, while Malaysia, Sri Lanka, Thailand and Vietnam among Asian countries showed a negative trend. Samoa had doubled the area. Though there is an increase in production as a result of the area increase, the production increase does not match with the total area under this crop. The coconut productivity in India is 0.92 ton copra/ha/year whereas the crop is capable of producing 3 to 6 tons of copra per hectare depending upon the input management. The productivity of Indonesia, Thailand, Vietnam and Sri Lanka are 1.05, 1.05 and 1.14 ton copra/ha/year respectively. The productivity in India was at lower rate at 0.22 per cent per year compared to Indonesia at 3.22 per cent Sri Lanka 1.91 per cent and Thailand 18.96 per cent.

Coconut oil *vis a vis* other oils

Coconut oil is one among the 17 oils and fats and has to compete with 16 other oils. In general, vegetable oil production has increased considerably during later part of 20th centuary. Soybean and palm oil have made tremendous increase from 3.30 million and 1.26 million tons to 30.68 and 30.45 million tons respectively from 1960 to 2004 with an annual growth rate of 19.3 per cent and 53.7 per cent respectively. For the same period the coconut oil production increased from 1.95 million to 3.02 million tons with a growth rate ranging between 0.36 per cent and 2.46 per cent up to 1990 and practically zero growth rate during the recent years. Similarly, the palm kernel oil increased from 0.421 million tons to 3.524 million tons with a growth rate ranging from 4.39 per cent during 1970-80 to 16.51 per cent during 1980-90,8.56 per cent during 1990-2000 and currently 7.74 per cent. Though palm kernel oil (PKO) and coconut oil as the major source of lauric oils have experienced set back due to price fall, it is noteworthy to observe the substantial increase of PKO over the years. It is likely to exceed the coconut oil (CNO) in due course, because of organised plantations of oil palm with optimum input management to get yields of 0.3 to 0.4 ton/ha of PKO in addition to 3 to 6 tons of palm oil/hectare/year. Coconut oil always faces problem because it has to compete with all cheaper oils. Now, virgin coconut oil has been introduced in the market, which may have a good market potential if proper market promotional efforts are made highlighting its wider use in functional foods and in the manufacture of pharmaceutical, nutriceutical and cosmoceutical products maintaining the quality standards.

Coconut consumption pattern

In terms of uses of coconuts within India, about 50 per cent is used for edible purpose or the religious purpose, about 31 per cent for coconut oil, about 8-11 per cent for tender coconut and about 8 per cent for edible copra. In Sri Lanka about 70 per cent are used for local consumption, 21 per cent for desiccated coconut, 5 per cent for coconut oil and 4 per cent for other purposes. While in Philippines, the export market is big (78.88 %), as they convert coconuts into as many value added products which have export demand and only 21.12 per cent is consumed internally.

Export Market

Coconut products like copra, coconut oil and desiccated coconuts are being exported since 1960. The export of copra has considerably decreased over the years due to the fact that the countries exporting copra earlier have started value addition, as indicated by increasing export of CNO and copra meal.

The United States and Europe are the primary markets for coconut products particularly coconut oil, desiccated coconut, copra meal, oleochemicals. In the case of coconut oil, the U.S. and EU take in more of crude coconut oil and cochin oil types. Similarly, desiccated coconut export goes mainly to the U.S. and EU which together accounts for 47.3 percent of total world import of desiccated coconut. Among the major, export products, desiccated coconut has the most diversified market. Last year, Philippine' shipment of desiccated coconut went to 71 country destinations. Copra meal export, on the other hand, has shifted from Europe which used to be the. leading export market, to Asia specifically South Korea and Vietnam. The swing has been largely the result of stringent allowable limit for aflatoxin contamination in Europe and a fast developing livestock industry in Asia. Export of oleochemicls which comprise coco fatty alcohol, coco fatty acid, methyl ester and glycerine also go mainly to the U.S., Europe and China for the soaps, detergents, surfactants and toothpaste industries.

A growing income improves purchasing capacity that fuels demand for vegetable oils, particularly in developing countries. Notably in China which has seen significant improvement in GDP of 14.5 per cent from 8.3 per cent in 2002 to 9.5 per cent in 2004. Per capita consumption of vegetable oils rose correspondingly by 16.7 per cent to 18.9 kilos per year in 2004 from 16.2 kilos in 2002, which indicates that the demand for coconut oil also will increase in future.

Product diversification

The exports of coconut oil, copra meal, coco chemicals and activated carbon have growth rate of 8.35 per cent, 5.05 per cent, 12.41 per cent and 34.42 per cent respectively over a period of 1990 to 2004. Annually, more than US$ 1 billion is earned through the export and the leading exporter is Philippines followed by Indonesia and Sri Lanka. Sri Lanka and India are the biggest exporters of coir fibre products followed by Thailand. The recent data indicated that there is growing demand for coconut products like coco cream, coco powder and coco chemicals in the world export market.

Lauric oil offers as raw material for oleochemical production such as fatty acids, fatty alcohols, methyl ester, which in turn find application in a wide range of surface active agents, among others, used in various consumer and personal care products. One of the biggest buyers of lauric fatty acid P & G disclosed that world demand for lauric fatty acid is 4.5 million MT annually of which one-third is consumed in the U.S. alone. World import of coconut oil averages 1.9 million MT and palm kernel oil at 1.7 million MT for a total of 3.6 million MT. Assuming a recovery rate of lauric fatty acid of 40 per cent, available supply from both sources combined would be 1.4 million MT. The huge supply- demand gap certainly is being exploited for the product divesification.

6.2. SWOT Analysis

6.2.1. STRENGTHS

- Has largest germplasm collections in coconut and arecanut
- Marching towards an advanced centre in molecular biology and biotechnology, farming system research, studies on Phytoplasma and Post harvest Technology including Value addition
- The crops dealt have wider adaptability to ecosystems
- Established management practices for sustained yield levels
- Time tested and proven technologies for adoption at farmers' level with scope for inter/multi/mixed crops.
- Innumerable products/byproducts of high economic value
- High employment opportunities for women, deprived and youth
- High potential for export of products and earnings in international markets.
- Health promoting food products and eco-friendly non-food items
- Great stake for agro-industries and community development.
- During seventies major thrust was on crop management, eighties it is for germplasm collection and conservation, nineties for biotechnology and Information Technology and current focus is on frontier areas like functional genomics, gene transfer, maximization of Total Factor Productivity, production and marketing of value added products and cyber extension.
- Strong, sound and coherent scientific, technical and administrative staff
- Special emphasis on Inter-disciplinary and Multi-Disciplinary projects

6.2.2. WEAKNESS

- Deals with perennial crops, in which the system dynamics is a long run process
- The research results and their benefits cannot be realized in short run as in the case of annuals
- Diseconomies in scale of production and marketing at farm level
- The agronomic and plant protection practices for the crop demands special type of skilled labour
- Mechanization is not possible to the desired level due to predominance of small and marginal farms
- Domestic market prices are based on demand and supply of few products of the mandate crops
- Lack of infrastructure for marketing
- Insufficiency in agro-based industries
- Unexploited potential of human resources for small/medium scale industries.
- Increasing number of senile and older plantations of coconut and arecanut
- Widening gap of demand and supply for elite planting materials

- Challenges in increasing Total Factor Productivity due to structural constraints such as predominance of small and marginal holdings, location specific nature of crop management practices and lack of system approach in farming
- Escalating cost of production due to higher cost of major inputs and low productivity
- Lack of market intelligence on various products of the mandate crops with reference to their domestic and international trade
- Lack of micro level strategies for reorienting subsistence farming towards market oriented farming
- Inadequate capital investment for commercialization of technologies in meeting the changing trend in global and domestic demand
- False myth on coconut and its products for human health
- Greater possibilities of import of cheaper substitutes for domestic use., eg, use of palm oil instead of coconut oil for culinary and industrial applications
- Non-competitiveness at global level
- Lack of interest of rural youth in accepting farming as a main profession

6.2.3. OPPORTUNITIES

- Evaluation of the largest number of germplasm for a given purpose/utilization
- Enhancement of knowledge through intensive training programmes
- Greater scope for adoption of technologies with refinement
- Involvement of community level approach for augmenting farm income
- Potential source for women empowerment through self-help groups
- Restructuring the market base linkages with agro-corporations/industries
- Excellent scope for product diversification and addition of high value to products like organic foods, virgin coconut oil, functional food, functional drinks from coconut, cosmoceuticals, bio fuel/bio lubricants, premium grade monolaurin from coconut for use in the medicinal field, pharmaceutical and dyeing application of arecanut, cocoa based value added products

6.2.4. THREATS

- Increasing degree of production and price risks in farming due to biotic, abiotic factors and international market forces.
- Sudden eruption of minor pests and diseases to major status
- Appearance of new pests and diseases lead to lower the productivity
- Natural calamities like cyclone, earthquake and tsunami affects mandate crop production levels

7. PERSPECTIVE

Coconut

Coconut is grown in more than 93 countries in the world in an area of 12.19 million ha producing 61,165 million nuts or 13.68 million tonnes of copra equivalent. Coconut oil is one among the 17 oils and fats and is now facing stiff competition from other vegetable oils. Soybean and palm oil, which are major competitors for coconut oil, showed 19.3 % and 53.7 % annual growth rate during the last four decades while coconut showed only 0.36 to 2.46 % increase up to 1990 increase and zero growth rate during the recent years. Coconut products like copra, coconut oil, desiccated coconut and other value added products are traded internationally. Global export of coconut products exceeds US $ 1.2 billion annually. The Philippines account for the largest export of coconut products earning about US $ 841 million a year exporting more than 50 coconut products, followed by Indonesia. In Philippines, the export market is huge (78.88%) as they convert coconuts into many value-added products which have export demand and only 21.12 % is consumed internally.

In India, the annual coconut production is 12833 million nuts from an area of 19.35 lakh ha. The realized average annual productivity of 6632 nuts/ha is the highest in the world. The coconut sector in India provides employment nearly to 10 million farmers and makes a contribution of nearly Rs. 7000 crores annually to GDP and contributes 6% to the vegetable oil pool of the country. The importance of the crop lies in the fact that it provides livelihood and sustenance for the millions of small and marginal farmers. In India, almost the entire production goes for internal consumption in the following pattern: about 47 % for edible purpose, 28 % for coconut oil, 11 % for tendernut and 6 % for edible copra.

Indian population is expected to increase to 1363 million in 2025 at an annual growth rate of 1.2 %. A growing income improves purchasing capacity that fuels demand for vegetable oils and functional foods. A change in the consumption pattern towards more of value-added products and exploitation of export potential of diversified products will enhance the demand for the crop. In the emerging scenario, the demand of coconut is expected to be 21,795 million nuts by 2025, while the supply is expected to be 15734 million nuts leaving a gap of 6061 million nuts. As there is no scope for area expansion, there is a need to increase the productivity to meet 100 % of the domestic demand, avoiding import and to channelise 20-25 % of the production for export of value-added products.

The competitiveness of coconut sector will largely depend on the productivity of the crop. Today one ha of coconut produces on an average only 0.6 tonne of oil whereas one ha of oil palm produces nearly 3-5 tonnes of palm oil. It necessitates high degree of productivity improvement to survive the onslaught of competition. Converting more of production to product diversification is the strategy suggested to make the crop competitive in the emerging scenario. Taking into consideration that coconut is grown mostly under rainfed conditions by resource-poor farmers, cost effective and affordable technologies should be developed for improving productivity.

- Development of resistant varieties for the diseases and drought could be a solution for increasing the productivity. In this context, frontier areas of biotechnology like association mapping and gene cloning will be utilized to develop stress resistant genotypes. Data base of genetic resources need to be developed for the better management of these resources to address the problems confronted by the crop. Alternate conservation of germplasm for disaster management strategies like *in vitro* conservation of superior genotypes and efficient regeneration protocols for coconut will be strengthened.

- Research strategies should focus on improving production and productivity, combating high incidence of pests and diseases, harvesting the full potential of coconut by product diversification and finding new applications for conventional products based on demand of coconut products.
- The country is unable to make any dent in the international trade as international prices of coconut products are lower than domestic prices. Reduction in cost of production is to be achieved by enhancing input use efficiency in irrigation, nutrient management, organic recycling, use of bioagents in the management of pests and diseases and crop nutrition, substrate dynamics, crop simulation modeling and farming system approach.
- The problems to be addressed include the low level of mechanization, marketing facilities and fragmentation of holdings. Extension strategies have to be modified to overcome the disadvantage of small scale of operation and move towards consolidation of holdings by adopting cluster approach and evolving group strategies.
- Development of machineries/implements to mechanise the farm operations and post harvest processing is warranted to meet the labour shortage in this sector.
- To reduce dependency of coconut price on coconut oil, a change in consumption pattern is warranted towards diversified products. The increasing demand for tender coconut water as natural health drink is a welcome trend and will continue to increase with the development of processing technologies. Product diversification efforts are expected to bring in lots of changes in the consumption pattern resulting in the diversion of greater proportion of production for value-added and diversified products, which will reduce the percentage of nuts used for copra making and coconut oil.

Arecanut

Myanmar, Indonesia, Bangladesh, Malaysia and China are the other major arecanut producers. The production and productivity data of Myanmar and Indonesia showed rapid increase during last two decades. In the years to come these countries may become major competitor, to arecanut in International and Indian markets.

At present, India produces 4.39 lakh MT of arecanut from an area of 3.64 lakh ha and the average productivity is 1202 kg/ha of fresh nut. The per-capita consumption in the hinterland is estimated at 2.01 g per eligible adult while in the consumption base it is 1.58 g per eligible adult. India exports whole betel nut to 22 countries of which Yemen Republic, Bangladesh and UK are the prime importers. To be competitive, So the emphasize should be on increasing the productivity and income per unit area. Major hindrance for increasing the productivity in arecanut is the widespread occurrence of Yellow Leaf Disease(YLD) and water scarcity in Karnataka and Kerala during summer months.

- Developing resistant varieties against YLD and improvement of management strategies for the disease should receive priority attention to address the problems of increasing incidence of YLD.
- Development of sustainable cropping system models involving low volume high value crops will be attempted to buffer the price fluctuation of main crop and to ensure sustainable income to areca growers.
- Production strategies to be refined to achieve higher input use efficiency and eco-friendly technologies for pest and disease control.
- Developing high yielding dwarf hybrids in arecanut will be continued to address the problem of scarcity of skilled climbers.
- Finding alternate uses of arecanut for increasing profitability of arecanut farmers should be another area of future research.

Cocoa

Brazil, Ivory Coast, Malaysia and Ghana are the major cocoa producing and exporting countries in the world. In India, this beverage crop is cultivated in about 27811 ha and the annual production is about 10,175 MT with a productivity of 530 kg/ha. In the country, cocoa is grown as intercrop or more precisely a companion crop under irrigated coconut and arecanut gardens. India exports cocoa butter, husks and shell, cocoa paste and cocoa powder and cake to many countries. The world per-capita cocoa consumption was around 0.525 kg. However, there are wide variation in consumption levels between regions. Europeans consume on an average 1.73 kg per had, Americans 1.3 kg, Asians 0.093 kg and Africans 0.146 kg. The production of cocoa beans hardly meets 30 % of the demand projected by the processing industry in India. As assessed, the demand of cocoa beans will be 72600 MT by 2025.

- To enhance cocoa production, area expansion should be undertaken in traditional coconut and arecanut growing areas as mixed crop under irrigated conditions.
- Developing resistant varieties for vascular streak dieback (VSD) and black pod disease of cocoa and mass multiplication techniques for propagating resistant varieties is warranted.

8. ISSUES AND STRATEGIES

8.1. Strengthening of ongoing research areas

Prevalence of biotic and abiotic stresses is a major constraint affecting the productivity of palms and cocoa. Root (wilt) disease of coconut and yellow leaf disease of arecanut are the two major diseases that cause considerable loss and even threaten cultivation of these crops in disease prevalent areas. Development of resistant varieties is the most economical and practical solution for the disease management in the long run. Drought is another major problem which needs to be managed through development of drought tolerant varieties.

Crop genetic resources are the raw material on which development of new varieties are based. Assembling maximum diversity in a crop at a place will greatly help the breeders in utilization of these resources. Molecular characterization of genetic resources will provide the basic data for effective utilization of these resources in breeding programmes. Data base of genetic resources need to be developed for the better management of these resources to address the problems confronted by the crop.

Due to increasing natural disasters leading to total loss of gene pools, there is need for alternate strategies like i*n vitro* conservation of superior genotypes and cryopreservation of germplasm.

Increasing number of senile and older plantations is identified as one of the major factors responsible for the low productivity of the crop in traditional areas. There is huge requirement of quality planting material to meet the demand of replantation programmes whereas the present production capacity of the Government agencies is limited. This warrants augmentation of quality planting material production and establishment of seed gardens in public and private sectors in various states by supply of breeders stock. Another strategy is the development of *in vitro* regeneration protocol for mass multiplication of quality planting material.

Total factor productivity is low in holdings due to structural constraints such as predominance of small and marginal holdings and lack of system approach in farming. The focus in this area will be to develop more sustainable cropping systems models by including compatible high value low volume crops that will optimise the utilization of natural resources and be readily adopted by farmers. The crop management strategies are to be optimised in such a way to harness the synergistic interactions and complementarities in the system and by developing soil quality indicators and indices to assess the sustainability of soil management practices. Livestock enterprises have to be incorporated along with cropping systems to increase and stabilize income and generate additional employment.

The productivity of the mandate crops is also constrained by unacceptably low input use efficiency. Inefficient use of resources has resulted in increased cost of production, reduced profitability and has detrimental effect on natural resources. Developing technologies that improve input use efficiency while safeguarding the natural resource base will greatly help in enhancing ecological and economic sustainability of production systems.

High biodiversity of beneficial microbes has been reported in tropical productions systems and technologies for utilizing these microbes are yet to emerge on a large scale. Development of effective formulations of agriculturally important micro-organisms viz. nitrogen fixers, phosphate solubilisers, plant growth promoting rhizobacteria (PGPRs), mycorrhizae and organic matter decomposers, and their applications to meet the nutritional requirement and to achieve plant growth promotion, can bring about sustainability in crop production scenario.

High market price fluctuations in the price of coconut and its products is due to dependency on the price of one product, coconut oil, which is again dependent on the cost of other vegetable oils. Thus, product diversification of coconut and development of value added products become very important in the coconut industry. Development of commercially viable technologies assume great significance. Developing process for the production of virgin coconut oil and standardization of quality parameters will enable large scale production of this valuable product with high export potential. Coconut oil is also rich in lauric acid, which is known for having antiviral, antibacterial and antifungal properties. Development of commercially viable technology for lauric acid production could result in the development of another profitable venture for augmenting income of coconut farmers. Thus, a full utilization of the edible parts of coconut is possible by optimising the production of value added products.

The skilled labour required for various operations such as climbing, dehusking etc is becoming scarce. Also high cost of hired labour is making coconut sector non-competitive. Development of labour saving machinery and implements for field operations and post harvest processing operational such as efficient climbing device, dehusking machines etc. is vital for the healthy growth of the coconut industry.

Crop loss due to pests and diseases is a major production constraint and hence crop protection umbrella for these major pests/pathogens would be crucial to increase production and productivity of these crops. Complex maladies such as root (wilt) disease (RWD) of coconut and yellow leaf disease (YLD) of arecanut are debilitating in nature and cannot be controlled by plant protection measures. Precise and early diagnosis of RWD and YLD through molecular approaches is important for the developing, screening techniques to identify the planting materials possessing resistance genes. Isolation of highly efficient Plant Growth Promoting Rhizobacteria with capacity for induced systemic resistance (ISR) and utilization of microbial resources as a value addition to the nursery management to produce robust and disease free plants at the nursery stage will help to a great extent in the management of the diseases.

Pest problems encountered by coconut palm cause production loss at varying proportions. A holistic approach for pest management integrating IPM and INM practices with the involvement of highly efficient bioagents, botanical pesticides, pheromones and biofertilizers is imperative to achieve higher success. In a high density intensified cropping system, both biocontrol agents and biofertilizers with a broad spectrum of activity can be utilised for effective biosuppression of the pests in the field.

Technology adoption is crucial to achieve competitiveness, profitability and sustainability in coconut farming. Several surveys revealed that the technology adoption is low to medium in different parts of the country. Extension efforts need to be widened so that the impact is trickled down beyond the vast area/ people interacted. Research-extension-farmer-market-development linkage is necessary to achieve faster trickling down of the technologies.

The advances in communication technology need to be effectively utilized to disseminate the technologies and to attain effective coordinations among various extension and developmental agencies. Cyber extension programmes assume great significance to develop linkages with various stake holders to address the various requirements of farming system. Development of multilingual website portal on technologies and production of e-learning materials on various aspects of farming are to be carried out.

On farm processing is a grey area primarily due to the predominance of small and marginal farms. Cluster or group approach is necessary to develop viable processing units. There is tremendous scope for organising women's Self Help Groups (SHGs) for food processing in coconut sector. Capacity building of members of women's SHGs for successful management of production and marketing of coconut based food products has to be given priority for product diversification in coconut.

Studies on policy and trade issues of plantation crops are vital to provide adequate information to various stake holders on marketing, trade and Government policies. Database on crop, marketing and trade statistics and policy matters are to be developed and analysed to provide advise on farming options, credit allocation, subsidies etc. Analysis of availability as well as utilization of institutional/other credit facilities in the farming sector and impact analysis of industries, SHGs, corporate sector in the farming scenario need to be carried out so as to make appropriate policy planning.

8.2. New Initiatives

Association mapping

Association mapping strategy would help to identify and tag gene(s) responsible for resistance to biotic and abiotic stresses. In the normal course, using conventional approaches, it takes a minimum of 18-22 years for evaluating the yield potential of the genotypes. Identification of molecular markers associated with quantitative traits will accelerate the breeding programme in the mandate crops. However, the long breeding cycle and the inherent heterozygosity hinder development of mapping populations for undertaking linkage mapping for identification of QTLs. The alternative approach to gene mapping (association, or linkage disequilibrium mapping) using associations at the population level, therefore, offers an opportunity to identify associations between marker patterns and trait expressions.

Identification of Candidate genes and gene cloning

Cloning and characterization of resistant genes for biotic and abiotic stresses, transformation studies and development of transgenic crops against pests and diseases and adverse environmental conditions with desirable quality parameters are the strategies suggested to address the problems in long run. Candidate genes associated with disease tolerance will be located in particular chromosome regions suspected of being involved in the disease or based on the study of protein products associated with resistance and also using resistance factors reported with other palm species/crops. Techniques like RT – PCR, differential display will be used to identify candidate genes induced during stress. These genes will be cloned into vectors, sequenced and homology with known stress responsive genes will be studied. Micro array technology will also be utilized for gene expression studies. The target genes so identified will be cloned and recombinant vectors will developed and gene expression of will be studied in plant systems.

Isolation and characterization of genes involved in fatty acid biosynthesis in coconut using molecular and bioinformatics tools. Isolation and tagging of lauric acid gene. Development of EST and SNP markers in coconut and arecanut using bioinformatic tools to gene tagging for biotic /abiotic stress.

Gene pyramiding

It is envisaged to combine into a single genotype a series of target genes associated with desirable traits, *viz.* tolerance to biotic/abiotic stresses, identified in different parents. This requires prior identification of desired target genes, which can be achieved through candidate gene approach or QTL/association mapping strategies. However, in long generation crops, this can be achieved better through development of transgenics, for which efficient transformation and regeneration techniques have to be standardized in the mandate crops.

Molecular and microbiological studies

The advanced molecular microbiological studies in plantation crops will help to map the rich diversity of AIMs in the rhizosphere of the main crop and inter/mixed crops through polyphasic research including microbiological techniques, biochemical characterization and PCR protocols.

Substrate dynamics

Substrate dynamics is a component with multiple functions of importance to soil fertility such as catalysis of nutrient transformation, storage of nutrients, formation and stabilization of soil structures and control of plant pathogens. An in depth study on the substrate dynamics will help in evolving strategies to increase the input use efficiency.

Carbon trading

With the industrial development at the peak, global climate is changing very fast. The impact of climate change on several plants has been studied in detail. However, such studies on coconut are to be initiated. Since coconut is a perennial crop and can act as a large carbon sequestration sink, it is essential to understand more about the cause-effects of climate change on coconut plantations with respect to the physiological efficiency for carbon sequestration, yield, etc. The coconut plantation can be used as a carbon sequester with high economic output.

Virtual water trade

There is no information on virtual water requirement of coconut and coconut products. Quantification of virtual water within the context of required and available domestic water resources will help to evaluate economic efficiency, water and food security, and sustainability, and to develop alternatives for improved water use efficiency. Hence research should be initiated on virtual water requirement in coconut and coconut based products.

Crop Simulation modeling

Modeling plant growth requires a description of the pools and fluxes of nutrients in different plant parts and soil as well as nutrient inputs and losses. Obtaining a complete description for one or more nutrient in an ecosystem is a formidable challenge and means that few exist. Thus, simulation model will help us in development of best management practice (BMP) for sustainable productivity in the coconut based cropping system.

Market Intelligence and Policy Research

Though India is one among the major producers of coconut in the world, lack of marketable surplus, higher cost of production, unorganized marketing and processing in coconut industry, keeps the country in disadvantageous position in the arena of International trade. In this context, the market intelligence and policy research in the present era of trade liberalization and globalization, would help plantation sector.

9. PROGRAMMES AND PROJECTS ON TIMESCALE FOR FUND REQUIREMENTS

Programmes	Time Scale		
	2007-2012	2012-2017	2017-2022
CROP IMPROVEMENT			
Collection of germplasm from indigenous and exotic sources for targeted traits for identifying the sources of resistance to biotic and abiotic stresses	✓	✓	✓
Evaluation of germplasm for drought tolerance and other biotic and abiotic stresses to superior resistant/ tolerant types for utilizing in crossing programmes for production of superior hybrids	✓	✓	✓
Large-scale production of released hybrids by crossing between varieties available in already established seed gardens	✓	✓	
Identification of elite high yielding mother palms in farmers' plots through participatory plant breeding methods for further enhancement of planting material production	✓	✓	✓
Breeding for resistance to root (wilt) disease and development of resistant varieties/hybrids	✓	✓	✓
Development of *in vitro* regeneration protocol through direct and indirect somatic embryogenesis from coconut, arecanut and cocoa	✓	✓	
Cryopreservation of zygotic/ somatic embryos and pollen of coconut and arecanut for long term *in vitro* conservation	✓	✓	✓
Use of association mapping strategy to tag molecular markers with agronomically important traits and marker assisted selection	✓	✓	✓
Development of SNP (single nucleotide polymorphism) and EST (expressed sequence tags) markers for coconut, arecanut and cocoa to characterize the germplasm collections of coconut, arecanut and cocoa	✓	✓	✓

Programmes	Time Scale		
	2007-2012	2012-2017	2017-2022
Development of microarray technology for gene expression studies	✓	✓	✓
Use of techniques like RT – PCR, differential display to identify candidate genes induced during stress	✓	✓	✓
Development of transgenics in arecanut, cocoa and coconut for quality improvement (Better fatty acid composition in coconut and less arecolin in arecanut)		✓	✓
Expression of human vaccines in coconut tender nut water (edible vaccines)		✓	✓
Creation of a molecular marker database for coconut germplasm characterization and cultivar identification	✓	✓	✓
Computational approaches in plantation crops like genomics and proteomics		✓	✓
CROP PRODUCTION			
Development of diversified and intensive farming systems with higher resource use efficiency and evaluation of recently released varieties of different crops/high value crops for shade tolerance in palm based farming system	✓	✓	✓
Quantification of nutrient stock, nutrient cycling and flows and energy management through simulation models in the Palm Based cropping system	✓	✓	
Application of remote sensing and GIS techniques for natural resource management	✓	✓	
Organic farming and substrate dynamic studies to develop self sustaining systems in coconut and cocoa	✓	✓	✓
Increasing water use efficiency and development of watershed based approaches in soil and water conservation measures using locally available materials for different soil types and topography	✓	✓	
Delineation of Micronutrient deficiency in major coconut growing tracks and their amelioration	✓	✓	
Identifying Critical Soil Information for Site-Specific Management and precision farming in coconut to maintain the soil health and increase the profitability to the farmer	✓	✓	✓
Development of Integrated Nutrient Management System with biofertilizer, organic and inorganic nutrient sources	✓	✓	

Programmes	Time Scale		
	2007-2012	2012-2017	2017-2022
Carbon Sequestration and microbial dynamics studies in coconut, arecanut and cocoa – Palm Based Cropping/Farming systems	✓	✓	✓
Rhizosphere engineering to favour agriculturally beneficial microbes and molecular studies on agriculturally important micro organisms	✓	✓	✓
Comparative analysis of the structures of soil microbial communities by genomic finger printing of bacterial communities	✓	✓	
Utilization of biofertilisers and plant growth promoting rhizobacteria (PGPR) in crop production	✓	✓	✓
CROP PROTECTION			
Purification and characterization of phytoplasma associated with coconut root (wilt) and yellow leaf disease of arecanut	✓	✓	
Sensitive molecular diagnostic techniques for major diseases	✓	✓	
Induced systemic and acquired resistance and application of PGPR	✓	✓	✓
Integrated pest and disease management : Coconut - bud rot, stem bleeding, root (wilt) and leaf rot Cocoa - vascular streak die back Arecanut - ganoderma wilt and yellow leaf disease Coconut - red palm weevil, rhinoceros beetle, eriophyid mite	✓	✓	
Epidemiology and disease forecasting and pest and disease surveillance for major pests and diseases of mandate crops	✓	✓	✓
Vector - host relationships	✓	✓	
Collection, conservation and characterization of biocontrol agents from different locations, development of bioformulations and mass production	✓	✓	✓
Semiochemicals-olfactory conditioning of parasitoids and synnamone in pest management	✓	✓	
Refinement and evaluation of pheromones	✓	✓	
Studies on the variablity within pathogen causing major diseases of coconut, arecanut and cocoa		✓	✓
Studies on emerging pests and diseases of coconut, arecanut and cocoa	✓	✓	✓
PHYSIOLOGY, BIOCHEMISHTRY			
WUE in coconut and cocoa as related to carbon isotope discrimination and estimation of virtual water requirement for coconut economic produce	✓		
Oil productivity, fatty acid composition and quality in relation to G x E interaction	✓	✓	
Superoxide dismutase – biochemical characterization		✓	✓

Programmes	Time Scale		
	2007-2012	2012-2017	2017-2022
Impact of climate change on growth, productivity and quality of coconut and cocoa (elevated CO_2 and temperature studies included)	✓	✓	
Crop simulation modelling for growth and yield of coconut and cocoa	✓	✓	
Carbon sequestration in coconut and cocoa and carbon trading	✓	✓	
Evaluation of cocoa varieties/ hybrids for drought tolerance under field condition	✓	✓	
Intensification of studies on alternative uses of Arecanut particularly polyphenols for pharmaceutical uses	✓	✓	
Storage studies of arecanut with regard to stability of biochemical components for future use	✓	✓	✓
POST HARVEST TECHNOLOGY			
Development of labour saving machinery /implements for field operations	✓	✓	
Development of technology for production of virgin coconut oil	✓		
Development of commercially viable technologies in product diversification and value addition	✓	✓	✓
Blending of coconut oil with other vegetable oils	✓	✓	
Development of a technology for production of monolaurin from coconut oil	✓	✓	✓
Development of quality testing devices	✓	✓	✓
SOCIAL SCIENCES			
Extend the scope of cyber extension programme and make use the (virtual) linkages with various stake holders to address the requirements of farming systems	✓	✓	
Evolving training strategies to impart skills to farm labourers	✓	✓	
Developing training and consultancy facilities to meet the requirements of corporate training	✓	✓	✓
Preparation of e-resources for training and education	✓	✓	✓
Establishing a media centre to cater the requirements of electronic media	✓	✓	✓

Programmes	Time Scale		
	2007-2012	2012-2017	2017-2022
Consumer preference studies in relation to product diversification programmes	✓	✓	
Agribusines related studies on production – supply and marketing chains	✓	✓	✓
Policy research with reference to mandate crops	✓	✓	✓
Knowledge management on trade statistics and policy issues which has capabilities capture and populate information from the Internet	✓	✓	✓
Analysis of trade and policies	✓	✓	✓
Production and price risks analyses	✓	✓	✓
Impact analysis of industries, SHGs, and corporate farming	✓	✓	
Changes in total factor productivity in different farming situations at different time intervals to indicate long term sustainability of the system	✓	✓	
Use simulation techniques for testing economic viability of newly evolved farm technologies	✓	✓	
Developing data mining tools to meet the requirements of agricultural insurance sector as well as of biotechnology	✓	✓	✓
Development of spatial database management information system		✓	✓
Establishing a unit on statistical quality control to cater the requirements of agribusiness	✓	✓	✓
Development and maintenance of multi lingual portal	✓	✓	✓
Application of image and video processing technologies for automate and analyze the wet lab experimental data	✓	✓	✓
Develop expert systems for farmers and extension personnel	✓	✓	

10. LINKAGE, COORDINATION AND EXECUTION ARRANGEMENTS

The institute has established linkages with various ICAR institutes, SAU's and other organizations like Department of Science and Technology, Department of Biotechnology and other organizations for integrated approaches towards sustainable development of coconut, arecanut and cocoa farming community. Following are the areas of linkages with various organizations.

FOREIGN

Asian Development Bank / Asian & Pacific Coconut Community

Development and field testing of IPM strategies for the management of coconut mite *Aceria guerreronis* Keifer

International Fund for Agricultural Development/ International Coconut Genetic Resources Network

Overcoming poverty in coconut growing communities: Coconut Genetic Resources for Sustainable Livelihoods in India. Molecular marker based characterization of conserved coconut germplasm and farmers varieties.

University of Reading, UK.

Cocoa germplasm collection in collaboration with NBPGR, New Delhi.

Asia / Pacific Regional Cocoa Breeding Initiative

To identify best lines of high yielding clones with resistance / tolerance to cocoa pod borer, black pod disease ,Vascular Streak Dieback and drought.

It is proposed to have linkage with Diversity Array Technology (DArT) Laboratory, Yarralumla, Australia Canberra for developing and validating new markers for diversity analysis of germplasm and association of traits and genes in coconut.

WITHIN INDIA

Department of Biotechnology, New Delhi

Development of a database for plantation crops for biologists

Mass production and use of biocontrol agents in the integrated management of coconut leaf rot disease

Coconut Development Board, Kochi

Large scale production of antiserum for the identification of disease free elite parental palm and certification of quality seedlings

Integrated pest and disease management of coconut in heavily root (wilt) disease affected districts of Kerala state to develop model coconut-farms

Mass production and demonstration of bio-control agents for the management of Stem bleeding disease, Rhinoceros beetle and Black headed cater pillar of coconut

Directorate of Cashew and Cocoa Development, Kochi

Disease surveillance in cocoa with special reference to wilt complex

Central Institute for Research on Cotton Technology, Mumbai

Creation of database on physio-chemical and structural characteristics of coir fibres

Kottakkal Ayurvaidya Shala, Kottakkal

Inter/mixed cropping of medicinal plants in coconut garden.

Developmental Agencies / SAU's

A close linkage between the community based organisation, SAU's and officials from Coconut Development Board / State Agriculture / Horticulture Departments for the effective implementation of TOT programmes.

11. CRITICAL INPUTS

11.1. Funds

The new programmes will be initiated by providing necessary fund allocation in the XI, XII and XII five year plans. The estimated fund requirement for the XIth five plan period will be Rs. 3500 lakhs under the plan and Rs. 7000 lakhs under non plan.

11.2. Manpower

The sanctioned manpower for the Xth plan period was 106 for scientific, 149 for technical, 91 for administration, 311 for sporting staff and 11 for canteen staff. In order to achieve the goals envisaged in the vision 2025 additional man power requirement in the following field of specialization: Agricultural biotechnology, bio-informatics, food technology, agronomy and agricultural extension is required.

11.3. Human resource development

Frontier areas of training	Institute where the training is available
India	
Transformation and gene expression studies	Indian Institute of Science, Bangalore
	ICRISAT, Hyderabad
	ICGEB, New Delhi
	CCMB, Hyderabad
Second messenger signaling in olfactory transduction in insects	Tata Institute of Fundamental Research – NCBS, Bangalore
Monoclonal antibody production	CCMB, Hyderabad
Abroad	
Molecular marker studies	Cornell University, USA
Functional genomics	Scottish Research Institute
National Institute of Agrobiological Sciences, Tokyo	Gene expression studies
Precision farming and yield zonation using advanced GIS tools	ITC –The Netherlands
Pressurized irrigation management systems for palms	Centre for International Agricultural Development Cooperation - Israel
Water management in high rainfall hilly terrain	International Agriculture Centre- The Netherlands
Palm based cropping system modelling	International Center for Research in Agroforestry - Nairobi, Kenya
Management of genetic resources *in vitro*	IPGRI, Rome
Policy issues in global genetic resources management	InWEnt, Germany / IPGRI
DGGE studies in soil microbiology	University of Florida, USA
Quorum sensing studies in plant beneficial microbial communities	Oregon State University, USA
PGPR studies	Auburn University, USA
Insect signaling and communication	INRA, Versailles, Route de Saint Cyr, 78026 Versailles Cedex, France
Kairomones and parasitoids	IACR, Rothanmsted

12. RISK ANALYSIS BASED ON SWOT

Risks in agriculture are broadly classified as production and price or market risks. Unlike in the case of annuals, the negative impact of risks is more severe in perennial crops like coconut, arecanut and cocoa, in which farm managerial decision cannot be revoked without much resource and financial loss.

Coconut

Though India ranks first in coconut productivity (in terms of nuts), in terms of copra equivalent, the country's average productivity is almost on par with the global productivity (0.92 MT/ha), which is lesser than other major coconut producing countries like Indonesia (1.05 MT/ha) and Sri Lanka (1.14 MT). This coupled with increasing domestic demand puts India in disadvantages position for performing as a major competitor in the International trade arena.

Though coconut is cultivated in more than 18 States and Union Territories, the four Southern States viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the major producers accounting for more than 90 percent in both area and production.

Production risk

Kerala state has the largest area and production of coconut in India. However, the productivity level is much less than in Andhra Pradesh and Tamil Nadu. This is due to the inherent characters of coconut cultivation such as predominance of small and marginal farmers; prevalence of six months of continuous dry weather is a common problem in the Northern zone, and widespread prevalence of root (wilt) disease in Southern Kerala.

Tamil Nadu is the second largest producer of coconut in India. The crop is mainly cultivated under irrigated conditions and the land holdings size is comparatively bigger than that of Kerala. Though the coconut farmers in Tamil Nadu are enterprising, unprecedented drought since 2000 for consecutive years has ruined the coconut industry in the State. The State always faced water scarcity for agricultural and non agricultural purposes. Hence the state, with a relatively higher level of productivity is often facing drought situation and the farmers in this State are overcoming this problem through over exploitation of ground water resources.

Karnataka State has the second largest area under coconut. However, the productivity is the lowest among the four States. The major reasons for low productivity are successive droughts in major growing tracts, Eriophyid mite infestation and wide spread attack of leaf eating caterpillar.

Andhra Pradesh has the highest level of productivity in India. The coconut growing belts are most fertile and farmers are highly progressive and innovative in technology evolution and adoption. However, due to agro-climatic factors, area expansion is possible only to a limited extent in this State and uncontrolled area expansion could lead to imbalance in the agro-ecosystems of the zone. The Coastal districts of this State are also prone for cyclonic storms during North East Monsoon seasons and the farmers are yet to systematically practice coconut - based farming/cropping systems on a larger scale.

Market risks

Though India is one among the major producers of coconut in the world, lack of marketable surplus, higher cost of production, unorganized marketing and processing in coconut industry, keeps the country in disadvantageous position in the arena of International trade, In this context, the market risks in the present era of trade liberalization and globalization, which would affect Indian coconut sector are

- Competition for market share for coconut products among the major producing countries
- Greater possibilities of import of cheaper substitutes for domestic use
- Negative campaigns against coconuts and its products
- Inadequate enforcement of product quality standards
- Uncertain supply and price fluctuations
- Lack of market promotional activities for value added coconut products
- Unorganized marketing and processing of coconut and its products
- Small scale of production and processing and lack of integrated approach in processing

Arecanut

India is the largest producer of arecanut in the world. Area and production of arecanut in India showed an increasing trend during the past 40 years. Karnataka, Kerala, Assam, Tamil Nadu and West Bengal are the important states growing arecanut. At present India produces 439300 MT of arecanut from an area of 3.65 lakh ha and the average productivity is 1202 kg/ha of fresh nut.

Production risks

The major production risks in the present era of trade liberalization and globalization are for arecanut production sector are

- Continuing area expansion relying on stable and higher market prices
- Predominant cultivation of local cultivars
- Prevalence of old and senile palms in major producing states viz., Karnataka and Kerala
- Widespread occurrence of Yellow Leaf Disease in Karnataka and Kerala
- Predominance of risk prone monocropping conditions

Market risks

Area expansion in arecanut has occurred indiscriminately which lead to higher degree of price fluctuations. Further the problem is aggravated due to declining consumer demand particularly among the youth. This leads to sharp decline in produce prices and economic loss to the arecanut farmers. This trend would continue unless the arecanut farmers realize that arecanut would not be a profitable crop on sustainable basis under monocropping situation. Hence they should be encouraged for improving the Total Factor Productivity based on farming system approach.

Cocoa

India is one among the producers of cocoa in the world. This beverage crop is cultivated in about 17800 ha and the annual production is about 10200 MT with the average productivity of 560 kg/ha. India exports cocoa butter, husks and shell, cocoa paste and cocoa powder and cake to many countries. UAE and USA are the major importers of cocoa beans, while the Netherlands, Poland, Kuwait and Egypt are the major importers of cocoa shells and husks. UK is the main importer of cocoa butter fat, while Nepal imports huge quantity of cocoa powder from India. In addition India also exports chocolate and confectionaries to more than 25 countries.

Production risks

- Widening gap between demand and supply of elite grafts
- Area expansion in non conventional areas of east coast
- Prevalence of cocoa wilt disease in major growing tracts of Karnataka
- Management of Vertebrate pest problems in relation to social taboos

Market risks

Cocoa is a minor crop in India, which makes the country to be dependent on other major producers for meeting the domestic demand. Though strategies are being made to increase the cocoa production in the country, the achievements are limited only to certain parts of the peninsular India and the North East. Under these situations, the following market risks are bound to occur in Indian Cocoa industry.

- Competition for market share among producing countries
- Dependency of industry from importing countries for their raw material requirements
- Uncertainty in production and demand for cocoa

13. PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The Annual Institute Research Committee (IRC) of the Institute undertakes evaluation of the progress of implementation of research programmes and finalizes the technical programme for the next year. The Director of the Institute is the chairman of IRC and a scientist nominated by the Director functions as the secretary. The progress of the research projects is also evaluated through the quarterly reports submitted. Besides IRC, midterm review of the projects are also undertaken in the second IRC conducted during August-September every year.

The Research Advisory Committee (RAC), constituted by ICAR with eminent scientists with expertise in different disciplines, undertakes the review of research programme and formulate recommendations to stream line the projects and initiate new programmes.

The Quinquennial Review Team (QRT) also undertakes critical and thorough review of research programmes and submits recommendations not only for improvement of the research programmes but also for overall development of the Institute.

The Project Monitoring and Technical (PMT) Cell is functioning in the Institute right from 1983 onwards. The main functions of this section are monitoring and co-ordinating the research projects in force in addition to dealing with technical matters of the Institute. The PMT section also maintains Research Project proposal in RPF-1 format, annual report in RPF-II format and the final report of each project in RPF-III format. The proposals and progress reports of externally funded projects from AP Cess Fund, NATP, DBT, COGENT/IPGRI/ADB and other agencies are also handled by the PMT section.

14. RESOURCE GENERATION

Apart from the allocation from the Indian Council of Agricultural Research (ICAR) under the Plan and Non-Plan, attempts will continue to be made to generate resources through externally funded projects from national and international agencies such as COGENT, ADB, DBT, CDB etc. Internal revenue generation will be augmented by increasing the production of planting materials of mandate crops, offering consultancy services, charging fees for the training programmes, sale of biofertilizers, biocontrol agents and patenting of technologies developed.

Mechanisms for internal resource generation

Crop Improvement

- Production and distribution of quality planting material in coconut, arecanut and cocoa
- Mass multiplication elite plantlets of coconut, arecanut and cocoa through tissue culture
- Rapid screening of disease free, healthy plantlets using molecular markers for raising disease free seedlings
- Imparting training in palm biotechnology, hybridization techniques and production of quality planting material

Crop Production

- Production and supply of vermicompost, earthworms, mushrooms, mushroom spawns, vermiwash, nucleus cultures of agriculturally important microorganisms
- Mass production and distribution of biofertilizers of agriculturally important microorganisms
- Consultancy services on crop management aspects and nutrient deficiency problems
- Consultancy services on soil and plant sample analysis from Government Agencies and planters
- Income generation through cultivation of remunerative crops and animal husbandry enterprises utilizing interspaces and vacant spaces in plantations

Crop protection

- Consultancy services on disease and pest problems in farmers gardens
- Mass production and distribution of biocontrol agents and antagonists

Physiology, Biochemistry & Post Harvest Technology

- Training to farmers/agril. officers/extension personnel on drought management in coconut
- Consultancy on fatty acid analysis of oil samples
- Sale of technologies of the new coconut and arecanut products and gadgets developed

Social Science

- National and International training programmes
- Sale of publications, CD ROMs

Fund and Revenue generation during IX, X (Actuals) and XI plan (projection)

Rs. Lakhs

	IX Plan (actuals)	X Plan (actuals)	XI Plan (projection)
Funds			
Plan	1032.77	1270.00	3500.00
Non Plan	4468.56	5868.24	7000.00
Revenue generation	630.69	615.25	750.00

15. OUTCOME OF INSTITUTION WITH TRADE, INDUSTRIES AND FARMERS

I. Coconut based agribusiness

Though India is one among the largest producers is of coconut in the world, its relative share in the international trade arena is non-significant as compared to other major coconut producing countries such as the Philippines, Indonesia and Sri Lanka. Lack of organized marketing having vertical integration with the agro-processing is the prime reason for the same. Technologies are available for individual processing for the production of snow ball tender nut, coconut chips, copra, vinegar, desiccated coconut, coconut shell powder, coconut shell charcoal, packed tender nut water, coconut cream and milk powder. Based on this, four types of agri-business models are suggested below.

Production of value added coconut products as an individual enterprise

a) **Snow Ball Tender Nut (SBTN):** It is a globular tender kernel with water rich in nutrient content suited for eating and drinking.

b) **Coconut Chips:** It is ready to eat dehydrated coconut slices prepared by osmotic dehydration of coconut kernel

c) **Coconut oil:** It is a vegetable oil extracted from dried kernel copra

d) **Copra:** It is a dried coconut with a moisture content of < 6%

e) **Vinegar:** An acetic acid prepared from coconut water used in pickle industry and fast food centres.

f) **Desiccated Coconut (DC)**: It is the dehydrated disintegrated coconut kernel with a moisture content of < 3% prepared from the matured coconut

g) **Packed tender nut water:** It is the storable form of tender nut water with necessary additives

h) **Coconut Shell Powder:** It is a powder prepared from matured coconut shell

i) **Coconut Shell Charcoal:** It is a charcoal prepared by burning matured coconut shell

j) **Coconut Cream:** Cream prepared from coconut milk extracted from the kernel of coconut

k) **Coconut Milk Powder:** Dehydrated coconut milk extracted from kernel of matured coconut

Investment analysis of production of coconut based value added products

S.No	Industry	Capacity (No. of nuts /day)	Quantity of products	Investment (Rs. In lakhs)	Gross Returns (Rs. in lakhs / year)
1	Snow Ball Tender Nut	500	500 numbers	2.00	0.54
2	Coconut Chips (Smaller Scale)	500	75 kg	3.00	27.00
3	Coconut Chips (Larger Scale)	10000	1300 kg	30.00	468.00
4	Coconut oil mill	10000	750 kg	6.00	135.00
5	Copra production	10000	1500 kg	6.00	135.00
6	Desiccated Coconut	10000	1000 kg	30.00	180.00
7	Coconut vinegar	10000	1000 l	8.00	36.00
8	Coconut Shell Powder	10000	1000 kg	13.00	60.00
9	Coconut Shell Charcoal	35000	1150 kg	13.00	17.25
10	Coconut Cream	10000	2500 kg	128.00	600.00
11	Coconut Milk Powder	20000	1000 kg	250.00	360.00
12	Packed Coconut Water	12500	2500 l	32.00	75.00

The economics of production of coconut based value added products as furnished above indicates that fairly high level of capital is required towards establishment and operation of these enterprises. For this institutionalized credit may be arranged through development agencies especially in those areas which are congenial for sustainable production and marketing of these products. Initially these firms may concentrate on domestic markets. Subject to meeting the requirements on quality standards, they can expand their horizons to the international markets. A huge amount of returns will act as the motivating. Further coconut farmers are expected to realize better price stability in medium to long run.

Small scale coconut based agro-industrial complex.

Indian coconut sector is predominated with small and marginal farmers and the scale of operation of the intermediaries is also limited. In this situation, it is rational for resorting to small scale coconut based agro-industrial complex, limiting the production and marketing activities to two or three products such as coconut oil, snow ball tender nut and coconut chips. The cost analysis of such a business for the production of 60 kg of coconut oil, 500 numbers of snow ball and 75 kg of coconut chips per day is furnished in the following table.

Cost economics of small scale agri-processing unit

S.No	Particulars	Value
01	Total investment	Rs. 550000
02	Capacity of the complex	1750 nuts/day
03	Number of labour required	10/day
04	Per day working capital	Rs. 12500
05	Gross Cost per day	Rs. 13000
06	Gross Return per day	Rs. 15000
07	Net return per day (after accounting for investment)	Rs.2000
08	Benefit-Cost Ratio	1.15

Coconut farmers could venture this on a group basis with or without the involvement of traders in urban areas. It could be inferred from the above table that the realized net return from this business could be to the tune of Rs.6 lakhs/year. The production cost could be further reduced if the raw material is procured within the farmer’s group and a part of the labour requirement is also met within them. Proper implementation of these models would pave way for better price stabilization for coconut products.

Medium scale integrated production of value added coconut products

In order realize better economies of scale, integrated production of value added coconut products can be taken in a medium scale. Subject to the availability of resources the same may be implemented by farmer’s groups. The number of products involved in the production may be restricted to five to seven. The cost benefit analysis of a similar business for seven products viz., coconut oil (120 kg/day), snow ball (500 nos/day.), coconut chips (35 kg/day), mushroom (15kg/day), coir yarn (1000 kg/day), coir pith compost (30 kg/day) and vermi-compost (30 kg/day) is furnished in the following table.

Cost economics of medium scale agri-processing unit.

S.No	Particulars	Value
01	Total investment	Rs. 550000
02	Capacity of the complex	1750 nuts/day
03	Number of labour required	23/day
04	Per day working capital	Rs. 19500
05	Gross Cost per day	Rs. 20000
06	Gross Return per day	Rs. 22700
07	Net return per day (after accounting for investment)	Rs.2700
08	Benefit-Cost Ratio	1.14

As in the case of small scale agro-processing unit, it could be inferred from the above table that the realized net return from this business could be to the tune of Rs.8.1 lakhs/year. This acts as a motivation for the farmers and entrepreneurs for adopting these models. The production cost could be further reduced if the part of the labour and raw material is met within the unit.

Large scale integrated Production of value added coconut products

Coconut based agro processing complex is a suggested long term investment with an initial expenditure of 121 lakhs for setting up processing units (including land and buildings) integrating copra, coconut oil, fibre, compost, shell powder, vinegar, desiccated powder and coconut chips for processing 25,000 nut per day. Based on the initial availability of the capital few or more components of these products can be integrated. Maximum investment (34.71%) is required for DC units and the minimum (1.65%) for compost unit. A total labour of 36,000 mandays is required. The average power requirement is 12750 units. The realized grass returns of various integrated coconut processing models over edible oil industry alone varies from 19.05% in case of DC powder to 98.4% in case of model VI. Though the present BCR of certain highly intensive model are lower as compared to low intensive models, in long run, subject to technology development and long run price trends, it is better to integrate more number of possible components. Such an integrated approach ensures better price stability for coconut and it products and stabilizers the gross farm income for coconut farmers. This would lead to better rate of adoption of technologies by the coconut farmers in different parts of the country and the overall productivity of coconut industry would improve.

Investment analysis for integrated coconut processing models was performed. The investment parameters were highly positive and increase with the degree of integrations. Combination of edible oil, DC Powder, Chips, Vinegar, Shell Powder, Industrial Oil and Oil Cakes proved to be economically viable and their economic worthiness is higher than the conventional edible oil production or DC powder manufacturing. It could be inferred from the table that investment in coconut based agro-processing is economically viable and the realized BCR ranged from 1.63 (Chips + Vinegar + Shell Powder+ Industrial Oil l+ Oil Cake from Testa) as compared to 1.18 in the case of edible oil alone. It could be observed from the table that though the BCR between the edible oil and DC is not significantly different, the additional NPW of 94.82 lakhs confirms the economic worthiness of investment in DC as compared to edible oil. Moreover DC has a steady domestic demand and price as compared to fluctuating coconut oil prices.

The Internal Rate of Return (IRR) is highly positive for all the agro-processing models which indicate that subject to the availability of other infra structures and other major inputs it is economically worth to start these industries by availing institutional credit.

The estimates of economic worthiness are made based on the domestic market conditions and prices. However those who are willing to start these units on a larger scale needs to understand the basics of international demand for diversified coconut products and the expected quality parameters at the international level.

II Outcome of the Institute with farmers

CPCRI along with the centers of AICRP of Palms evolved/ refined a number of technology solutions for growing coconut, arecanut and cocoa.

Supply of quality planting material

COCONUT

Varieties : Chandra Kalpa (Laccadive Ordinary)
Kera Chandra (Philippines Ordinary)
Chowghat Orange Dwarf (COD)
West Coast Tall (WCT)

Hybrids : Chandra Sankara (COD x WCT)
Kera Sankara (WCT x COD)
Chandra Laksha (LCT x COD)
Laksha Ganga (LCT x GBGD)
Ananda Ganga (ADOT x GBGD)
Kera Ganga (WCT x GBGD)
Kera Sree (WCT x MYD)
Kera Sowbagya (WCT x SSAT)

In addition, planting material of parental lines used in production of commercial hybrids viz., COD, WCT, LCT, GBGD, ADOT, SSAT, MYD, MGD, M0D, is supplied to farmers for establishment of seed gardens.

ARECANUT

Varieties : Mangala, Sumangala, Sreemangala and Mohitnagar

COCOA

Clones : I-14, I-56, III-105, NC42/94 and NC45/53

Hybrids : I-56 x II-67, ICS 6 x SCA 6, II-67 x NC42/94 and II-67 x NC29/66,

Crop management techniques

Nursery management, planting systems and care for young plantation, replanting or underplanting, cultural operations and integrated nutrient management techniques in arecanut, cocoa and coconut have been developed. Cocoa canopy management as under intercropping and as a sole crop, canopy architechture by pruning and selective cutting of branches have been developed.

Irrigation management technologies

For coconut, application of 200 litres of water by open irrigation once in four days is recommended. Drip irrigation of same quantity at 66% pan evaporation is also recommended from December to May. For arecanut 200 litres of water by open irrigation once in a week during November to February and 4-5 days from March to May and drip irrigation at 66% pan evaporation is recommended.

Cropping Systems

Coconut based cropping system with elephant foot yam, ginger, tapioca, clove, banana and bhendi as intercrops and high density multi species cropping system (HDMSCS) with different statured crops are well accepted technologies.

Arecanut based cropping system with black pepper/ betelvine, banana, lemon, pineapple/ colocasia, ginger/ turmeric are well accepted intercropping technologies.

Inclusion of dairy, poultry and fisheries for mixed farming proved to be best profit earning system under coconut/ arecanut cropping.

Mushroom cultivation (*Pleurotus* sp.) with coconut leaf and bunch wastes.

Coconut and arecanut waste utilization by composting and vermicimposting.

Drought management by husk burial in coconut and farm waste mulching in arecanut and cocoa are proven technologies.

Integrated management technologies for major diseases and pests in arecanut, cocoa and coconut have been developed

Development of post harvest technology equipments

Developed and popularized agricultural machinery such as coconut climbing device, buckling device, coconut dehusking equipment, copra and arecanut driers and nut splitters along with recently developed snow ball tender nut machine and tendernut punch & cutting machine.

Coconut products

The technology of production of desiccated coconut, chips and snow ball tender nut has been transferred to many entrepreneurs.

Others

Various analytical and diagnostic services for soil, water and plant related problems are extended to farmers and agencies.

Recent transfer of technology activities and farmer-scientist interactions have developed pragmatic approaches towards plantation productivity enhancement, poverty reduction and sustainable growth. Entrepreneurship development and orientation for women and youth are part of the transfer of technology efforts.

16. EXPORT POTENTIAL AND MARKETABILITY OF RESEARCH OUTPUT AND ITS IMPACT IN WTO REGIME

From Uruguay round of WTO agreement till the latest Doha round, many issues in agriculture were brought into the multilateral negotiations. There are also other agreements which are related to agriculture like Sanitary and Phyto-sanitary measures as well as Trade Related Intellectual Property Rights. Basically it dealt with liberalization in three major areas viz., market access, export competition and domestic support with an agreement which was to be implemented both by the developed as well as the developing countries.

The market access basically says that various types of barriers to trade like quantitative restriction, and ban on imports have to be removed and need to be converted back into equivalent tariff. All non-tariff barriers have to be converted into ordinary bound customs duties. These bound duties have to be reduced over a period of time. By doing so, the trade becomes more open and hopefully fair. Second important area is the export competition. Export subsidies actually create a lot of distortions in the world market and therefore we should move away from providing export subsidies for the agricultural commodities. The other important issue is the domestic support – the amount of subsidy that we provide for various commodities as well as for non specific product subsidies like irrigation subsidy, electricity subsidy and so on. All these support measures put together should not exceed certain limit, if they are exceeding, they should be reduced.

India does have certain strength in producing many agricultural products, but in case of coconut and cocoa India may not be competitive. The competitiveness in the international market is about three major things - one is the inherent ability to produce a particular product. For example, coconut cannot be grown well in all places. Usually it grows well in coastal areas and in certain agro climatic conditions which are much better suited. Therefore inherent ability usually depends on the geography of the nation itself. The second one is the ability to develop comparative advantage. For example, if India could be able to come up with better varieties, better methods of production and so on, then the country can actually enhance the comparative advantage. The third important thing is the ability to develop competitive advantage, which is basically the quickness with which the country can streamline the systems such as post harvest technology and value addition so that Indians able to deliver the product to the consumer effectively and efficiently. On the inherent ability India may not be able to do much. But for a crop like coconut, the country has large areas suitable for its production. But in terms of enhancing comparative advantage and also streamlining post harvest systems, several initiatives have to be undertaken in order to improve the competitiveness.

Export potential

Coconut and its products

The overall export of coconut and its products from India including coir increased from Rs.745.5 million during 1991-92 to Rs.5181.0 million in 2004-05. Coconut oil fetched maximum export earnings of Rs.294.54 million among the products other than coir, followed by coconut shell powder, oil cake, coconuts, desiccated coconut and shell charcoal. There is still vast scope to increase export earnings from coconut and its products. Coir and coir products alone earned Rs.4586.13 million during 2004-05. In the import coconut oil (refined) and oil cake were main items imported to India.

Export of Coconut Products from India (Qty in Tonnes, Value in Rs. million)

Sl.No.	Item	2002-2003		2003-2004		2004-2005	
		Quantity	Value	Quantity	Value	Quantity	Value
1	Coconuts (fresh)	473.45	8.03	610.32	7.01	935.43	10.07
2	Coconuts (dried)	714.46	23.18	594.61	22.91	583.80	25.63
3	Copra	0.00	0.00	196.00	1.63	3049.76	21.08
4	Desiccated coconut	482.05	15.02	332.07	6.86	431.93	4.93
5	Other coconuts – excluding fresh/dried	-	-	196.98	5.51	796.42	16.85
6	Coconut oil	-	-	-	-	-	-
	(a) Coconut oil (crude)	160.57	5.83	224.33	10.15	434.61	20.47
	(b) Coconut oil (refined)	5515.47	232.27	5789.24	248.29	5519.75	273.97
7	Oil cake (defatted)	6434.92	31.98	285.62	3.29	1229.43	5.71
8	Coconut shell (raw)	580.60	10.28	266.36	8.32	301.61	7.55
9	Shell charcoal	7587.96	91.77	9351.00	110.91	2976.00	61.04
10	Shell Hukah	11.30		73.51	1.27	4.40	0.14
	Total		**418.368**		**426.15**		**447.44**

Import of Coconut Products into India (Qty in Tonnes, Value in Rs. million)

Sl.No.	Item	2002-2003		2003-2004		2004-2005	
		Quantity	Value	Quantity	Value	Quantity	Value
1	Coconuts (dried)	15.20	0.22	-	-	-	-
2	Copra	0.00	0.00	-	-	1500	28.16
3	Desiccated Coconut	24.00	0.43	8208	325.52	169	8.05
4	Coconut oil			23300	695.68	24600	685.95
	(a) Coconut oil (crude)	16652.48	346.97	-	-	-	-
	(b) Coconut oil (Refined)	13763.46	276.68	-	-	-	-
5	Oilcake (including defatted)	26181.19	145.98	52700	202.34	84800	280.67
6	Coconut shell charcoal	11.00	0.46	-	-	-	-

Source: Director General of Commercial Intelligence and Statistics, Kolkatta

Arecanut

Since India is the largest producer of arecanut the country would continue to play predominant role in global arecanut trade. However, the vision for this should focus on

a) Increasing the competitiveness through higher productivity in the production sector

b) Constantly monitoring the level of international demand and improving the quality of the produce exported and

c) Strengthening the research on post harvest technology and exploring the possibility of producing new products from arecanut.

Cocoa

India's role in the international cocoa market is insignificant. Cocoa has been found to be a profitable crop as majority of the production comes from intercropped plantations. The demand for cocoa is always higher than that of the production. The scenario in India is also not different. While the current demand stands at 1.4 million tonnes, the production meets only 15% of the demand. This necessitates import of cocoa to an extent of 50%. Even in this situation, India could export cocoa products valued Rs.286.9 million. This growth is from the base level of Rs.84.4 million in 1998-99. This is a clear indication that there is immense potential for value addition of cocoa and thereby exports to demanding countries. Among the various products chocolate confectionery was the major items exported. In 2004-05, 4177 tonnes of cocoa beans were imported into India valued Rs.395.10 million.

Export of Cocoa Products (Quantity – Tonnes, Value- Rs.Lakhs)

Description	2000-01		2001-02		2002-03		2003-04		2004-05	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value	Qty	Value
Cocoa beanswhole/broken/ raw/ roasted	181.9	11.25	21.2	7.21	12.2	10.97	15.1	11.48	30.7	23.62
Cocoa powder ofcoating sugar/ sweetening material	284.5	305.11	221.6	237.74	30.0	25.57	15.9	7.15	44.4	29.94
Other food productscontaining cocoa	254.8	215.83	357.1	439.73	399.0	626.10	6.8	10.64	12.4	21.61
Chocolateconfectionery	453.9	434.93	579.8	659.71	483.0	475.01	1552.1	1827.41	1266.3	1758.20
Cocoa shells husksskins & others	0.1	0.44	161.7	10.85	32.0	4.24	0.0	0	6.0	1.84
Cocoa butter fat & oil	187.5	390.29	8.5	5.19	Negligible		66.1	91.14	686.9	1033.80
Other food productspreparations	9.3	9.38	11.0	16.87	,,		0	0	0	0
TOTAL		1367.23		1377.30		1141.89		1947.82		2869.01

Import of Cocoa Beans

YEAR	QUANTITY (MT)	VALUE (Rs in million)
1999-2000	1422	103.49
2000-2001	2027	114.70
2001-02	2149	115.50
2002-03	1213	107.44
2003-04	1337	114.20
2004-05	4177	395.10

Marketability of research output and its impact in WTO regime

Among the several challenges confronting the coconut production, especially in terms of achieving competitiveness through higher productivity, the root (wilt) disease is the most important one. This disease is caused by phytoplasma and the major solutions are integrated crop management and breeding for resistant/ tolerant varieties. The research programme initiated in this regard has given encouraging results and needs to be intensified further.

Eriophyid mite has emerged as a major constraint to coconut production in all the coconut growing regions of the country. Considerable damage is also caused for coconut by other pests. The modern trend of research programmes in crop protection is towards reduced use of plant protection chemicals / planting tolerant varieties and developing integrated pest management practices are of utmost importance.

Recurring drought is experienced by coconut palms in the major coconut growing tracts of Tamil Nadu and Karnataka, adversely affecting the coconut productivity. Popularization of drought tolerant varieties and drought management strategies in the drought prone areas is the major way of mitigating the problem.

In most of the coconut growing countries, 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 through community nursery system involving farmer's association and widen the genetic base for the future breeding programme.

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 low yield potential. Though a number of high yielding varieties have been released, the country's capacity for the production of these planting materials has not kept pace with the demand. Therefore, there is an urgent need for strengthening the seed production capabilities not only to meet the requirements for area expansion but also to replace the senile and old palms. This also can be undertaken through community nurseries involving farmer's associations

Except for copra making and oil milling there are no major industries on coconut products. Prices of copra and coconut oil in India are much higher 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. Technologies are available for production of wide range of coconut based value added products. These technologies can be commercialized both as individual and integrated manner through proper planning and support, which would help in long run for achieving sustainable growth of coconut industry.

India is the largest producer and consumer of arecanut in the world. 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 level of existing plantation.

Shift in demand supply equilibrium would lead to sudden price fall, posing serious economic loss to arecanut farmers. Under these situations, adoption of arecanut based farming systems with other remunerative crops and allied enterprises would assure stabilized gross farm income and mitigate the probable financial loss to the farmers.

Research and developmental activities on alternate uses of arecanut products have to be intensified.

Cocoa is a minor crop in the country. This is mainly cultivated as a mixed crop in arecanut and coconut gardens. Research and developmental efforts on increasing the production and productivity levels of cocoa should be focused and the successful technologies may be popularized among the farmers and other clients in coordination with development agencies.

In order to tackle the challenges arising out of WTO, certain market oriented policies are to be taken up by Government of India. The primary aim on this is to rationalize the import tariff and other barriers to discourage and control the flow of import of coconut based products into Indian markets. For this, open end discussions between Agriculture and Commerce ministries should be held. Then, realistic estimates on the consumption pattern for coconut and arecanut, cocoa and their products in domestic and international markets has to be undertaken using consumer survey techniques. Simultaneously, seasonal demand and supply forecasts for the mandate crops have to be estimated using appropriate forecasting techniques. Finally, constant monitoring of parameters related to production and market intelligence needs to be carried out, to have constant watch in production and marketing parameters at national and international markets.

17. UTILITY OF RESEARCH OUTCOME TO FARMERS AND END USERS

Plantation crops like coconut, arecanut and cocoa are prone for high degree of production and price risks. Due to increase in consumer awareness, the domestic demand for value added products is expected to increase in medium to long run especially in urban India. Utility of research outcome to farmers and end users can be in the form of agri-business enterprises in which entrepreneurs and farmers can capitalize this situation for small//medium/large scale production and marketing of plantation crop based value added products.

In the case of coconut, production and marketing of elite planting materials of HYV/hybrids, coconut based cropping / farming system models, organic farming technologies, small and medium scale production of value added products can be utilized for starting various agri-business units mainly for the farmers as individuals or in groups.

Technologies are available for individual processing for the production of edible oil, DC powder, vinegar, coconut chips, shell powder, industrial oil and cakes. However due to their small scale operation the economies of scale and their relative profitability is low as compared to those, which could be achieved through scientific integration. A study indicated that scientific integration of different coconut based processed products would be economically viable as compared to their individual production. The existing individual units of coconut based agro processing, say edible oil and DC units, may be integrated with the by-products, say shell and water, utilizing units on a smaller scale to realize better net returns. In these units, involvement of family labour would considerably reduce the cost of production of diversified coconut products and increases the overall benefit cost ratio of the industry. Establishment of these units in those areas with less labour cost proves to be more beneficial. Appropriate developmental schemes may be formulated and effectively implemented in these aspects for achieving better price stability for coconut and its products in the domestic markets. Since integration of various agro processing units of coconut involves heavy investment, entrepreneurs who are willing to invest in few of these low or high intensive models, needs to undertake an assessment of the demand and supply pattern of in puts and possible domestic and international demand.

In the case of arecanut, production and marketing of elite planting materials of HYV, arecanut based cropping / farming systems, organic farming technologies can be undertaken as agri-business enterprises by the farmers.

In the case of cocoa, production and marketing of elite grafting materials and cocoa based value added products can be undertaken as agri-business enterprises by the farmers.

18. ANTICIPATED CONSTRAINTS

- In the post liberalization period, the main thrust would be on ‘quality’ so as to make our plantation products competitive in the light of opening up of the economy under the WTO Agreement on Agriculture. Insistence on stringent technical requirement such as quality certification and phytosanitary certificate is expected as a major constraint
- Lack of strategies for improving the marketing capabilities such as value addition, integrated processing, market promotion techniques and packaging
- Poor documentation of indigenous germplasm which may put the country in disadvantageous position in Trade Related Intellectual Property Rights
- Increasing cost components and prevailing terms of trade against the produce prices of the mandate crops
- Lack of aggressive market promotion techniques for competitive and substitute products of the mandate crops especially for coconut and its products
- Fluctuating export and import potential and marketability of products of the mandate crops.
- Probable emergence of exotic pests and diseases from unknown sources.

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