Vision 2030

Central Plantation Crops Research Institute
(*Indian Council of Agricultural Research*)
Kasaragod

www.cpcri.gov

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Central Plantation Crops Research Institute
(Indian Council of Agricultural Research)
Kasaragod 671124
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Compiled and Edited by
George V. Thomas
S. Jayasekhar
B. Augustine Jerard
P. Subramanian
John George

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Published by
Dr. George V. Thomas
Director, CPCRI
Kasaragod
Kerala 671124
Phone: 91-4994-232894, 232895
Fax: 91-4994-232322
e-mail : cpcri@nic.in
Web: www.cpcri.gov.in

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डॉ. एस. अय्यप्पन
सचिव एवं महानिदेशक
Dr. S. Ayyappan
SECRETARY & DIRECTOR GENERAL

भारत सरकार
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FOREWORD

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

Plantation crops in India are considered to be the major segment of the horticulture crops and provide livelihood to millions of farmers and those in trade. Central Plantation Crops Research Institute (CPCRI) has made significant contribution to enhance production, productivity and quality of coconut, arecanut and cocoa through generation of appropriate technologies by harnessing the prowess of science and technology. Today, India is among the leading producers of plantation crops. However, new challenges are emerging in the plantation crops sector in form of fragmented land holdings, pests and diseases, nutrient use efficiency, senility in palms, etc. which needs to be addressed, strategically and effectively.

It is expected that the analytical approach and forward looking concepts presented in the *'Vision 2030'* document will prove useful for the researchers, policy makers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

17th June, 2011
New Delhi

(S. Ayyappan)

Preface

Changing plantation crops scenario warrants innovative strategies and approaches to address new challenges and march towards an accelerated growth of plantation sector to achieve competitiveness and sustainability. It becomes highly important for small holder plantation crops which contribute immensely as the mainstay of the agrarian economies of many states and Union Territories in the country. Central Plantation Crops Research Institute (CPCRI), the pioneer national institute mandated to conduct research on coconut, arecanut and cocoa, has played a pivotal role in research and extension activities to ensure technology-led development of these crops in the country. The research efforts of the institute extending to over nine decades have yielded fruitful results in terms of increased production and productivity through high yielding varieties, development of cropping and farming system models for increased profitability in different agro-ecological zones, pest and disease management technologies and processing technologies for value addition and product diversification.

However, demand and supply projections of mandate crops indicate a widening gap in the coming decades due to the burgeoning population and change in food habits. Thus, it would be a challenging task to meet the demand in the future and improve our present position in the global scenario. It is a matter of concern that new challenges are emerging in the plantation crops sector which needs to be addressed strategically and effectively. In this context, the systematic effort to envision the challenges and opportunities and formulate a strategic approach by preparing 'CPCRI Vision 2030' is very much significant.

I take this opportunity to place on record our sincere gratitude to Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE and Dr. H.P. Singh, Deputy Director General (Hort.) for their valuable guidance and encouragement that we were fortunate to receive. The efforts made by the editorial team at the Institute to compile the 'CPCRI Vision 2030' deserve appreciation.

I have great pleasure in presenting the Vision 2030 of this Institute. It will be our honest endeavour that the vision embodied in this document is translated into reality in the near future.

28th June, 2011
Kasaragod

(George V. Thomas)
Director

Preamble

Plantation crops sector is an important segment of horticulture in India, which has shown significant growth in production and productivity during the last few decades. In case of coconut, the major plantation crop of national and international importance, the country is in number two position in global production and is first in productivity in terms of number of nuts produced per hectare of plantation. In case of arecanut, India is in an enviable position, being first in area, production and productivity. The fast rate of area expansion taking place in cocoa in recent years is indicative of the increasing acceptance and rapid growth of this sector. All these have been made possible by the advancements in research including high yielding varieties, production and protection technologies coupled with the developmental strategies being undertaken by the Government.

However, the plantation crops sector is now confronted with a number of challenges which has resulted in declining farm income, deterioration of production environment, total factor productivity, incidence of pests and diseases, shortage of labour force and the looming threat of climate change. The paradox is that in the present scenario of integrated global markets, we are not a key market player in determining the international market parameters. To face these challenges, the inherent weaknesses have to be converted to opportunities, and technology has to be the prime mover to achieve sustainable growth of the plantation sector.

Central Plantation Crops Research Institute, the pioneer national institute mandated to conduct research on coconut, arecanut and cocoa, has played a key role by making advancements in research and generating technologies to stimulate the process of development of these crops. The institute will continue to be vigilant and responsive to the changing scenario through development of innovative technologies and promoting problem-solving knowledge products.

In the present global scenario, it has now become evident that coconut requires to be promoted as a food crop for nutrition, health care and environmental services to safeguard the interest of millions of people and their livelihood. It is necessary to rope in global partners for collaborative programmes to address the long-standing and complex problems like phytoplasmal diseases. Efforts have to be intensified to gainfully utilize new frontiers of science and technology, which would include an understanding of structural and functional genomics, long term conservation of genetic resources through cryopreservation, problems of phytoplasmal diseases and its management, increased use of nanotechnology in disease diagnostics, targeted delivery of biomolecules, bioprocessing and smart packaging of value added products, unveiling the health benefits of coconut, leveraging environmental benefits through sequestration of carbon, as net carbon sinks and its benefit, product diversification and mechanization for sustainable use of coconut to provide quality life to the people.

The future programmes in arecanut research will focus on developing high yielding varieties and hybrids which are dwarf in stature and adaptable for high density planting, encouraging the farmers to adopt arecanut based cropping system integrating crop residue management and promoting alternative uses especially antimicrobial and anticariogenic activity of the phyto-chemical constituents. Promoting area expansion of cocoa as an ideal mixed crop in arecanut and coconut gardens to meet the growing market demand, characterization of compounds contributing to flavour and therapeutic properties and identification of clones for specific flavour and further studies for quantifying the carbon sequestration potential of cocoa will receive renewed impetus for the development of this sector.

In this backdrop, the 'CPCRI Vision 2030' articulates a set of well thought-out goals and delineates a roadmap for realization of the objectives envisaged.

Contents

1.89 million hectare area with a per hectare productivity of 8303 nuts. Kerala is the leading coconut producer in the country with an annual production of 5803 million nuts, followed by Tamil Nadu which produces 5365 million nuts annually. Coconut production in the country has increased from 12678 million nuts during the year 2001 to 15730 million nuts in 2009 with 3.5 percent compound growth rate of production. Productivity also has shown an upward trend from 6952 nuts per hectare in 2001 to 8303 nuts in 2009.

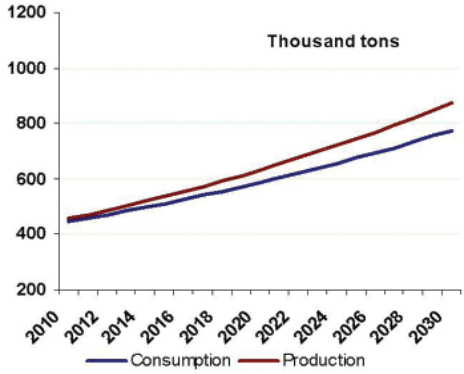
Arecanut

Arecanut is another important plantation crop, which plays a prominent role in the religious, social/cultural functions and economic life of people in India. Arecanut provides a decent livelihood for more than three million people and assured employment of 10 million mandays annually.

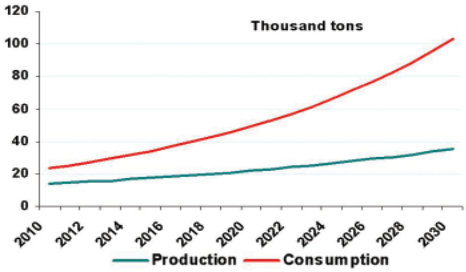
The present production of arecanut in the world is about 0.854 million tonnes from an area of 0.702 million hectares. India ranks first in both area and production of arecanut. In India, arecanut is cultivated in an area of 396.8 thousand hectares with an annual production of 559 thousand tonnes. Karnataka, Kerala, Assam and West Bengal are the major producers. Stagnating market prices and increasing cost of production, especially the skilled labour charges in the recent times have generated livelihood concerns of arecanut farmers in India. Surging imports, which is around 12 percent of the domestic production, certainly has a significant role in price stickiness. Market studies reveal that around 75 percent of the arecanut trade is in the hands of private traders, which has certainly provided ample scope for hoarding and resulted in market imperfections and low price realization. A check in additional area expansion and encouraging the farmer to adopt arecanut based cropping systems by strengthening the Transfer of Technology (ToT) activities would certainly benefit the arecanut farmers in the long run.

Cocoa

Cocoa is a potential commercial crop, mostly grown as a mixed crop in arecanut and coconut garden, which contributes about Rs.2000 million annually to the GDP of the nation. It is mainly cultivated in four



Demand and supply scenario of arecanut



Demand and supply scenario of cocoa

through the use of modern research tools, which can facilitate improving production of coconut in the country.

The estimated demand in the case of arecanut by 2030 is 890 thousand tonnes against the estimated supply of 790 thousand tonnes. Considering the market growth in the chocolate segment in India, which is about 20 percent per annum, cocoa has a great potential to develop in future years. The demand of cocoa during 2030 is estimated as 100000 tonnes against the estimated supply of 38000 tonnes.

Coconut and arecanut based production systems - economic viability, food and nutritional security

In the evolving trade liberalization regime, sustaining coconut cultivation as a profitable enterprise is extremely challenging. Hence the policies should focus more on competitiveness through higher productivity. One way to achieve this goal is through reduction in cost of production or in other words increasing the net returns. There are possibilities of increasing the productivity and net returns from coconut gardens by raising compatible subsidiary crops and/or integrating with livestocks. The farming system models of CPCRI have conclusively proved that the scientifically designed coconut-based farming system is not only capable of generating higher income, but also enhancing the employment potentials of small-holders. In a scientifically laid out coconut based farming system, unlike the traditional ones, the resource

From one ha of coconut based integrated faming system comprising coconut, pepper trailing on coconut trunk, banana in the interspaces of coconut, dairy unit (8 cows), fodder grass (hybrid bajra Napier Co 3), poultry (100 broiler birds/ batch), Japanese quails (100 layers) and aquaculture (1000 fingerlings) recorded an yield of 22050 numbers of coconut, 15097 lit. of milk, 460 kg of broiler birds, 4628 numbers of Quail eggs, 400 kg of fish, 1989 kg of banana, 300 kg of pepper and 500 cu meter of biogas with a net income of Rs. 168196/ha/year.

The economic advantage of high density multi species cropping system in root (wilt) disease affected coconut gardens over mono cropping was 61 % with a BC ratio of 1.59 indicating that the coconut based HDMSCS is economically viable provided the disease incidence is well managed by adopting integrated practices and other production and price related risks are at normal level. Analysis of root (wilt) disease incidence from the experimental field indicated significant reduction in the disease incidence due to adoption of integrated management practices.

Maintenance of dairy unit (cows and calves) in root (wilt) disease affected coconut gardens by raising fodder crops (Hybrid bajra napier-Co-3, azolla and stylosanthes) and cultivating compatible intercrops and utilization of crop biomass as well as organic manures (cow dung, cow urine and bio gas slurry) through recycling in the cropping system is found to be self sustainable in terms of nutritional requirement of coconut and other component crops.

An attempt to quantify the economic impact of arecanut based cropping systems was carried out in Dakshina Kannada region of Karnataka during 2009. It was observed that, farmers are predominantly following three cropping systems namely, 1) arecanut + banana 2) arecanut + cocoa and 3) arecanut + banana + pepper. These systems were compared with the percentage of adoption of each cropping system. The total economic impact due to adoption of cropping systems in the region was found to be Rs 819 million and the percentage increase in net returns from systems 1, 2 and 3 over monocrop were 32, 40 and 44 respectively. It was observed that the percentage adoption of arecanut monocrop was 26, while it was 36, 11 and 27 for system 1, 2, 3 respectively. The quantification of economic impact of each system has been worked out by combining the difference in net returns of each system from the arecanut monocrop, and and percentage of adoption of each cropping system.

production by about 3 lakh nuts/year for 4 years. Productivity loss was to the tune of about 3500 nuts/ha/year. Similarly, a cyclone in 1996 in Godavari District of Andhra Pradesh affected the nut yield for 6 years and the estimated loss was 2200 lakh nuts/year. Preliminary simulation studies carried out with the Infocrop-coconut model revealed that the coconut production in East Coast is more likely to be affected compared to West Coast with future climate scenarios.

Plantation crops are not only grown for their valuable products, but also they act as barrier to soil erosion of coastal regions and contribute substantially to the soil carbon stock. Coconut has a very high carbon storage capacity (24 ton ha-1 year-1) and hence, coconut lands could be developed for income generating carbon sequestration projects and carbon credit market. Further research is required to identify productive and sustainable coconut farming ecosystems that act as potential carbon sinks and minimize the effect of climate change.

Coconut based agri-business in India

Agro-processing is now regarded as the sunrise sector of the Indian economy in view of its large potential for growth and likely socio-economic impact specifically on employment and income generation. Some estimates suggest that in developed countries, up to 14% of the total work force is engaged in agro-processing sector directly or indirectly. However, in India, only about 3% of the work force finds employment in this sector, underscoring its underdeveloped status and vast untapped potential for employment. If properly developed, agro-processing sector can make India a major player at the global level for marketing and supply of processed food, feed and a wide range of other plant and animal products. There exists a huge scope for coconut based agri-business in India with reference to processing and value added products. Technologies are available for individual processing for the production of snowball tender nut, coconut chips, copra, vinegar, desiccated coconut (DC), coconut shell charcoal, packed tender nut water, coconut cream and milk powder. The economics of production of coconut based value added products indicates fairly high level of capital requirement towards establishment and operation of these enterprises. Nevertheless, the attractive returns from the business will act as the motivating factor and moreover, coconut farmers are expected to realize better price stability in long run.

Mandate

- To develop appropriate production, protection and processing technologies for coconut, arecanut and cocoa through basic and applied research
- Act as a national repository for the genetic resources of these crops
- Produce parental lines and breeders' stock of plantation crops
- Develop improved palm based farming systems through more effective use of natural resources to increase productivity and income from unit area
- Collect, collate and disseminate information on the above crops to all concerned
- Co-ordinate research on these crops within the country and execute the research programmes under the All India Co-ordinated Research Project on Palms
- Transfer technologies developed at CPCRI to the farmers through the co-operation of Developmental Departments/ Boards by sponsoring training programmes, workshops, demonstrations, etc.

Technological advancements

CPCRI, being the global leader in coconut research, maintains the world's largest repository of coconut germplasm with 398 accessions (consisting of 266 indigenous and 132 exotic genotypes) from 28 countries. Through intensive breeding experiments, five coconut hybrids involving talls and dwarfs as parents and nine high yielding varieties have been released for commercial cultivation. These improved hybrids and varieties are capable of yielding up to 4 tonnes of oil/ha annually.

Largest collection of arecanut germplasm, consisting of 141 indigenous and 23 exotic accessions (total 164) is being maintained at CPCRI, RS,

Gene Analogues (RGAs) were cloned and characterized from coconut using degenerate primers. Under the Bioinformatics initiative, several comprehensive databases for the mandate crops have been developed.

CPCRI has developed production technologies for coconut, with several cropping/farming systems involving annuals/biennials/perennials grown in different tiers by exploiting soil and air space more efficiently and integrating with poultry and animal husbandry. Coconut and arecanut based inter/mixed, multi storied multi-species cropping systems developed at CPCRI are being widely adopted by the farmers. The high density multi-species cropping system and coconut based mixed farming system helps to maximize profits and can even buffer the price crash of the main crop. For maximizing economic returns, high value medicinal and aromatic crops, vanilla and flower crops have been recommended in the palm based cropping system. Thevam variety of black pepper had recorded significantly higher dry berry yield (1.71 kg/vine) when grown as a mixed crop in coconut garden.

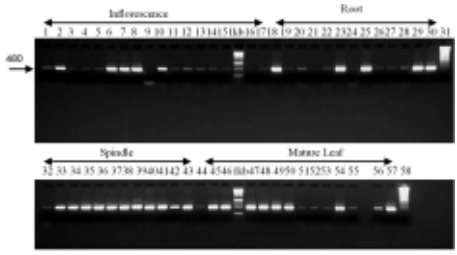
Water requirement for coconut, arecanut and palm based cropping systems have been standardized. Fertigation with 50 % of recommended NPK and 75 % of recommended NPK resulted in higher yield in coconut and arecanut, respectively. In coastal sandy soil management, pineapple, banana, elephant foot yam and vegetable crops like brinjal can be profitably cultivated as intercrop in coconut garden by adopting adequate soil moisture conservation methods. The Institute has developed various bio-engineering measures to sustain crop production in rainfed areas of west coast region. The low cost water harvesting structures developed by the Institute has helped in augmenting ground water recharge to a great extent, wherever installed. The Institute has made rapid strides in developing organic farming technologies. The vermicomposting technique using coconut, arecanut and other farm wastes by means of

When evaluated in the field, pheromone loaded in nanoporous delivery matrix trapped 424 beetles in 20 weeks.

Evaluation of new molecules against red palm weevil revealed the effectiveness of imidacloprid. In addition, granules of two green labelled insecticides *viz.,* flubendamide and chlorantraniliprole were also found to be promising. The biopesticide, *Menma* (developed by CTCRI from cassava leaves) evaluated against red palm weevil (@ 20 ml/ grub) caused 100% mortality under cup based bioassay and its field evaluation is in progress.

The optimum trap density of the refined PVC trap was found to be 1 trap/5 ha area, with the highest catch of rhinoceros beetles. Leaf axil filling with botanicals *(Pongamia* cake - 250 g with equal volume of sand) and Chlory Dust (6.0 g along with 250 g sand) showed promising results. Besides, constant vigil is being kept for all invasive and alien insect pests of mandate crops.

ELISA for the detection of root (wilt) using polyclonal antibodies has been refined further to a simple and very rapid test. The phytoplasma associated with the root (wilt) disease was characterized as belonging to16S rDNA XIV group and is related to sugarcane white leaf phytoplasma, Bermuda grass white leaf phytoplasma and the coconut Weligama wilt of Sri Lanka with >95 % similarity. Hot spot survey and identification of disease escapes and breeding programme using them resulted in the development of disease tolerant hybrids. For management of root (wilt) affected gardens, an integrated management strategy involving nutrient management through application of organic manures along with chemical fertilizers, cover cropping in the basin etc., along with adopting mixed cropping and mixed farming enterprises is recommended.



Recently conducted field trials indicated placing perforated sachets containing Mancozeb in the innermost leaf axils around the spindle leaf as a very effective prophylactic measure for

Studies on preservation and processing of coconut sap and haustorium into high-value natural and nutritious food products are underway. Heat pump drying of haustorium slices at 60°C for 8 h has resulted in distinctly bright coloured dried product. Efforts were made to develop fortified pasta utilizing the haustorium powder. The quality parameters for the processed coconut sap have been worked out and studies on its shelf life are in progress. Modification and evaluation of the processing gadgets/equipments like manual coconut slicing machine, biofuel dryer and the biofuel virgin coconut oil cooker are underway and it is expected that these equipments would considerably reduce the cost of production of the value added products.

Over the years, strenuous efforts have been made to adequately promote the mandate crops of the Institute through effective extension activities including trainings, farmer participatory approaches in technology development and dissemination, participation in exhibitions and conducting kisan melas, and production and distribution of planting materials of mandate crops.

The two Krishi Vigyan Kendras under the Institute (at Kasaragod and Kayamkulam) have always been on the forefront of helping the farming community in the respective districts. Besides, Agricultural Technology Information Centre (ATIC) operational at CPCRI, Kasaragod serves as single window access for the farmers, ever since its inception.

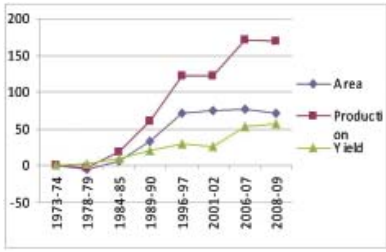
In the present digital age, cyber extension through videoconferencing and other IT enabled services has been increasingly resorted to as an efficient delivery tool for reaching out to the clientele. Transfer of technology is further strengthened with the addition of mobile video conferencing system to further promote the research-extension-farmer interface. Multimedia CD - ROMs on management of coconut, arecanut and cocoa were developed.

Impact of technologies developed

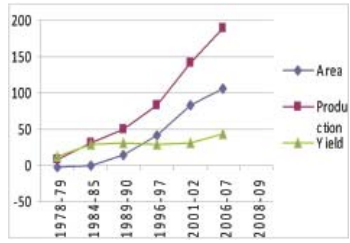
It is expected that through increased adoption of the developed technologies, farmers and processors would be able to increase the productivity and returns from their ventures in cultivation and processing of coconut, arecanut and cocoa in the country. In addition to the technical

contributed towards the overall growth of area, production and productivity of the mandate crops *viz.,* coconut, arecanut and cocoa.

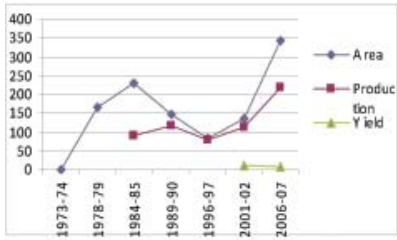
The overall performance in growth of area, production and yield of three mandate crops has been computed with percentage increase/ decrease in various plan periods over the end year of Fourth Plan (1973-74). In the case of coconut, growth in area was predominantly significant from the end of Fifth Plan onwards till the end of Eighth Plan. Production reached its peak during the 10th plan and in the year 2007 India has become the world leader in coconut production. The growth in productivity is remarkable especially from Eighth Plan onwards, the major factor which contributed towards the large production despite the stagnant area expansion in the case of coconut. In the case of arecanut we may observe consistent growth throughout the plan periods. In the case of cocoa, the growth rates are remarkable since the Eighth Plan.



Coconut



Arecanut



Cocoa

Percentage growth in various plan periods (1973-74 taken as base year)

- Protecting and improving the land, water, microbial and climate resources essential for sustained advances in the productivity, profitability and sustainability 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.
- Promote adaptation and mitigation strategies for climate change and to evolve mechanisms for crop and water management.
- Enhancing the income, livelihood, nutrition and health security of farm families through mutually reinforcing package of technologies.
- Promote innovations and improve human resource capacity involving all stakeholders in plantation crops.
- Foster linkages and collaborations with public and private, national and international organizations.

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. Molecular characterization of genetic resources will provide the basic data for effective utilization of available genetic resources in breeding programmes. Identification of molecular markers associated with quantitative traits will accelerate the breeding programme.

The future research areas in coconut would look into the use of bioinformatics, biotechnology, remote sensing, decision support system, precision farming and nanotechnology for developing technologies which can facilitate improving production of coconut in the country. The emerging challenges could be addressed effectively through utilization of tools like bioinformatics and biotechnology. Bioinformatics and biotechnological tools are being employed for understanding the phytoplasma associated with coconut, development of databases on coconut germplasm, molecular marker database and analysis tool such as "Phyloclass" for characterization of phytoplasmas. In future, computational tools would aid in high-throughput sequencing data analysis of coconut genome, genomics assisted selection and mapping the resistance genes.

The productivity of the mandate crops is also constrained by unacceptably low input use efficiency. 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. There are possibilities of increasing the productivity and net returns from coconut gardens by raising compatible subsidiary crops and/or integrating with livestocks. As the scientifically designed farming system models are capable of generating higher income, increasing the employment potentials of small-holders and achieving sustainable production, multi-tier cropping systems need to be promoted along with integrated farming systems in different agro ecological situations.

Remote sensing technique using space-borne sensors is a powerful tool for obtaining repetitive, synoptic observations on spectral properties

Crop loss due to pests and diseases is a major production constraint and hence a 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 conventional plant protection measures. Precise and early diagnosis of RWD and YLD through molecular approaches is important for developing screening techniques to identify the disease-free planting materials.

Pest problems encountered by coconut cause production loss at varying proportions. In a high density intensified cropping system, both biocontrol agents and biofertilizers with a broad spectrum of activity can be utilized for effective biosuppression of the pests in the field. 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 productivity.

High market price fluctuations in the case of coconut and its products are due to dependency on the price of one product - coconut oil - which is again dependent on the price 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. The technology developed for virgin coconut oil production needs to be upscaled to achieve large scale production of this valuable product with high export potential. Coconut oil is also rich in lauric acid, which is known for 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 optimizing the production of value added products.

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 organizing

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 analyzed to provide advice 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. The strategies to overcome the present turmoil in coconut sector suggest the need for further intervention to enhance technology adoption through the generation of technologies for different agro ecological situations.

In the evolving trade liberalization regime, sustaining coconut cultivation as a profitable enterprise is extremely challenging. Hence, the policies should focus more on competitiveness through higher productivity. One way to achieve this goal is through reduction in cost of production or in other words increases the net returns.

A paradigm shift in placing the coconut from an oil seed crop to food crop is also important and this can be made possible by diversifying and popularizing the value added products from coconut among the consumers. Enhancing farm level income through productivity improvement and other production measures, product diversification and subsequent demand creations for the new products are the need of the time.

c. Development of good agricultural practices

5. Developing cropping system models with high carbon sequestration efficiency, integrating animal husbandry, waste biomass recycling and utilizing beneficial microbial resources.
   a. Integrated cropping/farming system approach for resource use efficiency, higher carbon sequestration efficiency and nutritional security
   b. Conservation Agriculture/Organic farming technology for quality production and waste biomass utilization
   c. Consortia-based Bioinoculant development for plantation crops
6. Developing diagnostics for early detection of phytoplasmal and fungal diseases.
   a. Sequencing whole genome and annotation of RWD and YLD phytoplasma
   b. Development of diagnostics for coconut root (wilt) disease and arecanut yellow leaf diseases
7. Management of plant health through utilization of biointensive approaches and development of forecasting models for fungal diseases.
   a. Development of disease forecasting models
   b. Development of integrated disease management modules
   c. Evaluation of new pesticide molecules and search for bioagents against major pests of palms and cocoa
   d. Surveillance on invasive and emerging pests and pest risk analysis
   e. Nanoporous matrix for pheromone delivery
8. Value addition, product diversification and upscaling technology for commercial dimensions.
   a. Development of new value added products
   b. Pharmacological studies in arecanut and studies on flavour components and quality of cocoa
   c. Physiological and biochemical studies to improve the shelf life of products from mandate crops

Epilogue

As a pioneer in plantation crops research, CPCRI is committed to enhancing productivity of coconut, arecanut and cocoa for improving the livelihood opportunities of farmers, ensuring sustainable farming and agricultural growth. Through the first two decades of this century, India could attain an enviable position in the global scenario with respect to crop coverage, production and productivity in our mandate crops. However, the stiffer challenge is to retain the present advantage especially in the wake of stiff competition and perceptible climate change effects. In the present scenario of integrated global markets, the paradox is that though we are facing a number of challenges, we are not a key market player in determining the international market parameters.

Apparently, there is a need for bold initiatives that would transcend conventional boundaries of science and geographical delimitations for bringing about unprecedented success. Global initiatives are required for tackling long-standing and complex problems like phytoplasmal diseases of coconut and arecanut. Path-breaking efforts are warranted to overcome the current system which prompts farmers to opt for more remunerative cash crops like rubber, especially in traditional coconut growing areas in Kerala. This would overcome the stagnation especially in crop coverage and transform it into a vibrant, competitive and profit- making sector. Hopefully, our research efforts will be able to unleash such crucial initiatives.

On this optimistic note, let us embark on this long and arduous journey and we are sure, the success is bound to be ours.

Goal	Approach	Performance measures
Establishment of mother blocks of promising varieties	Quality planting material in mandate crops	Production & supply of breeder seeds
		Production of planting material of improved varieties
	In vitro multiplication in coconut, arecanut and cocoa	*In vitro* plantlet regeneration protocols for coconut, arecanut and cocoa
Coconut complete genome sequencing, diagnostics and microbial resources	Genome purification and preparation of libraries for sequencing,shot gun sequencing	Whole genome sequence of coconut, pathogens and microbial resources
	Generation of ESTs of coconut, re-sequencing of the genome, assembly of the sequence, gene prediction, functional annotation	Diagnostic kits
	Development of computational tools for crop improvement in coconut	New computational tools to improve the development and application of molecular breeding systems
Integrated cropping/farming system approach for resource use efficiency, high carbon sequestration efficiency	Development of location specific cropping /farming system models to meet the nutritional security	Location specific profitable, sustainable and higher resource use efficient palm based farming system models
	Carbon sequestration in palms and palm based cropping systems for mitigation of climate change, estimation of green house gas (GHG's) emissions under different system and under different management practices	Technologies and cropping/ farming systems for higher carbon sequestration efficiency
	Screening of released varieties of different high value crops as intercrops in palm	

Goal	Approach	Performance measures
Impact assessment of climate change on coconut, cocoa and arecanut, adaptation and mitigation	Analysis of weather parameters at different agro-climatic zones of arecanut and cocoa cultivation	Crop management strategies for climate change, elevated CO_2 conditions
	Calibration and validation of simulation model Info-crop to simulate the growth and yield of cocoa and arecanut	
	Simulation of future scenarios of coconut, arecanut and cocoa production using Info-crop model	
	Validation of model simulated results with Open top chamber (OTC) studies involving the interaction between climate variables like high CO_2 and elevated temperature with drought and nutrients. Also examine whether these studies can be taken up for elevated CO_2 using FACE facilities	
	Biochemical and molecular approaches for abiotic stress tolerance and production potential of coconut and cocoa	Identification of biochemical traits of tolerance to drought.
		Quantitative and qualitative estimation of drought, high temperature effect on crop production.
		Identification of flooding responsive proteins, lipids and carbohydrates.
		Identification of important stress tolerance genes in coconut
Developing diagnostics for early detection of fungal diseases	Collection of weather data from disease endemic areas, recording disease incidence at monthly intervals, and correlating with weather parameters and development	Efficient disease forecasting models

Goal	Approach	Performance measures
		and using active components for preventing cariogenesis of teeth
	Fractionation and identification of flavonols in cocoa beans/ Analysis of compounds contributing to cocoa flavor like pyrazines, polyphenols and purines in relation to clonal variations	Selections of cocoa clones for flavour compounds
Development of tools and machineries for reduction of drudgery and labour saving	Efficient and safe climbing devices for coconut/ arecanut Remote controlled devices Machinery for processing value added products	Development, Evaluation and Modification of Processing Gadgets/ Equipments
	Commercialisation of technologies	
Up-scaling technology transfer through ICT tools, participatory/ community based approaches and refinement of technology delivery mechanisms	Validation and refinement of technology delivery mechanisms, participatory extension management programmes, interactive/ collaborative and capacity building programmes, technology integration and participatory assessment	Efficient ToT systems integrating ICT tools
	Cyber extension programmes	
	Development of ICT applications, preparation of e-learning lessons	Web portal for plantation crops
	Studies on global and domestic commodity chains, trade agreements	Price forecasting, yield prediction models, market intelligence systems through policy research
	Impact assessment	Application of impact assessment models