



New Vistas in Plantation Crops Research

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Introduction

Indian plantation crops sector encompassing high value commercial crops has been the driver of rural economy in the tropical regions of the country by sustaining livelihood and elevating the socio-economic status of millions who depend on these group of crops for cultivation, processing, value addition, marketing and export. The strength of plantation crops to enrich the agrarian economy of the country lies in their capacity to earn considerable foreign exchange by way of export besides generating employment to millions particularly in the rural sector. Though these crops do not occupy substantial area compared to the other agricultural crops, their contribution to the GDP of the country is significant. Being perennial in nature, they have a stellar role in preserving and fostering ecological balance by preventing soil erosion and providing vegetative cover throughout the year to the agro-ecosystem and are carbon sequesters of considerable significance. As a perennial source of food, drink, medicine and raw material for a number of small and large scale industries, the history of these crops is interwoven with socio-economic and cultural lives of people in the rural sector.

The utility of these crops for a range of purposes including the versatile crop coconut for a variety of food products and natural fiber, coffee, tea and cocoa for beverages, cashew for edible kernel, oil palm for edible and industrial oil, rubber for natural rubber, arecanut for masticatory nut and spices adding flavour and taste to food and as medicine, make them an indispensable ingredient in the life of each and every human being. Estate crops such as tea, coffee and rubber are mostly grown in organized sector, while the small holders

plantation crops including coconut, arecanut, cocoa, cashew and a range of spices are predominantly grown in small and marginal holdings.

Scenario analysis of plantation crops

The country has leadership role as the largest producer of coconut, arecanut, cashew and spices and as a major player in other plantation crops (Table 1; Fig. 1). The dominance of the country in certain crops is being challenged now due to the emergence of new players. Coconut production touched 15840 million nuts which is the highest ever production achieved in the country and the productivity of 8165 nuts/ha is also the highest recorded so far. But in terms of copra productivity, the country does not possess a lead position. Tea production in India during 2006 was 8.0 lakh tonnes and it contributed 27.1% of the world production.

Table 1. Area, production and productivity of plantation crops and spices in India (2006-07)

Crop	Area (ha)	Production (mt)	Yield (kg/ha)
Coconut	19,40,000	15.84*	8,165**
Arecanut	3,96,800	5,59,200	1,409
Cashewnuts	8,54,000	6,20,000	726
Cocoa	30,341	10,180	530
Coffee	3,81,560	2,88,000	755
Tea	5,95,000	8,00,000	1,387
Rubber +	6,05,000	8,53,000	1,410
Black pepper	2,46,000	69,000	280
Cardamom	95,800	14,000	186
Turmeric	1,86,000	8,37,000	4,500
Ginger	1,05,900	3,70,300	3,497
Oil Palm	1,01,128	36,753●	367.53●

*million nuts; ** nuts /ha; + Natural rubber; ● palm oil

Data Source: CMIE database "Indian Harvest" 2008; FAOSTAT 2009; DCCD; DASD; CDB

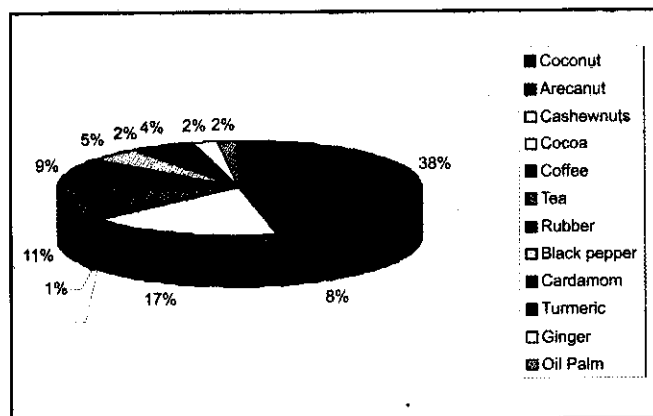


Fig. 1. Percentage area distribution under different plantation crops

The production of coffee remained stagnant in the range of 2.70 to 2.80 lakh tonnes for the past 5-6 years. The rubber sector achieved spectacular growth in terms of area expansion, increase in production and productivity. The production which was 15,839 tonnes in 1950 increased to 8,53 lakh tonnes during 2007 and the productivity increased from 284 kg/ha to 1,410 kg/ha during the same period. India is the leader in the world cashew economy in terms of raw nut production, kernel processing and export. The import of huge quantities of raw cashew nuts has become necessary to cater to the needs of processing factories. The spice production in the country is in the order of 4.31 million tonnes from an area of 2.66 million ha. The productivity of black pepper was 281 kg/ha during 2006-07 and the area under the crop was 2.46 lakh ha. Declining volume of exports is an important issue to be addressed in the trade of spices. Cocoa is cultivated in an area of 30,341 ha and the annual production is 10,180 tonnes and productivity is 530 kg/ha. The production of cocoa beans meets only 30% of the demand projected by the processing industry in India and there is need to promote cocoa production in the country. Oil palm is the highest oil yielding crop with a potential of yielding 6-7 t oil/ha and there is scope to increase the area to meet the increasing demand for vegetable oil. The country accounts for more than 50% of world production of arecanut.

Plantation crops contribute significantly to the export earnings of the country to the tune of over Rs. 7000 crores by way of export of various commodities (Table 2). Cashewnut contributed the highest value of Rs. 2,475 crores during 2006-07 by export of cashew kernels processed in the factories in the country. Coffee and tea are the other two commodities contributing significantly to the export earnings. India maintained its fourth position in world exports of tea with an export of 181.32 tonnes valuing Rs. 1,844.99 crores. The export

of coffee is to the tune of 1.88 lakh tonnes providing export earning of Rs.1,432.01 crores. Coir and coir products are major contributors for the export earnings from coconut. Spices also contribute considerably to the export earnings from the plantation sector. Though the country had premier position in export of certain plantation commodities, the declining trend in the volume of exports is a major concern.

Table 2. Export of plantation crops and spices from India (2006-07)

Commodity	Export Quantity (mt)	Value (Rs. crores)
Coconut Oil	3,677	22.83
Coir products	1,68,754	605.16
Arecanut	3,458	23.31
Cashewnuts	1,21,124	2,475.23
Cocoa	3,065.8	40.11
Coffee	1.88*	1,432.01
Tea	181.32*	1,844.99
Rubber	52,285	476.35
Black pepper	2,71,432	257.77
Cardamom (S)	650	22.36
Cardamom (L)	1,500	16.95
Turmeric	51,500	164.80
Ginger	7,500	39.75
Total	-	7,421.62

*lakh tones; *million kg

Data Source: CMIE database "Indian Harvest" 2008; FAOSTAT 2009; DCCD; DASD; CDB; Coir Board

Constraints in plantation sector

The country has sound research infrastructure to meet the research requirements in plantation crops. The research on coconut, arecanut, cocoa, spices, cashew and oil palm are carried out by ICAR institutes while research on coffee, rubber and tea are undertaken by respective boards. Despite the achievements in the plantation crops sector, much more needs to be done for future growth of the sector.

Several constraints are adversely affecting the production and productivity of plantation crops. Inadequate supply of quality planting material to meet the growing demand is a major constraint. Biotic and abiotic stress account for loss of about 25% value of agricultural produce. Hence, development of varieties with resistance to biotic and abiotic stress assumes significance. Unprecedented degradation of land, water and biodiversity resources have led to deterioration of soil health. Total factor productivity is decelerating. Global climate change has become a reality and is adversely affecting the productivity impacts on production. There is a shift of work force from agriculture

to non-agricultural sector. Cost of production is escalating due to the increasing cost of inputs and services. Due to globalization and trade liberalization, there is drastic fluctuation in price and international prices are more than Indian prices in many cases.

Challenges

The challenge now is to produce enough to meet the growing demand and generate more income without compromising the sustainability of our natural resources and the environment. Action is necessary on several fronts including technology, policy, infrastructure, market and finance. As there is no scope for enhancing the area, the only option for achieving competitiveness, sustainability and profitability is enhancing productivity. Technological innovations and applications are imminent to achieve sustainable productivity. Stiff competition from new players in the international trade is another challenge in plantation crop sector. Price competitiveness and quality of produce are the issues to be addressed to have competitive edge in international trade. In the era of globalization and liberalization of trade, the competitiveness in plantation sector lies on increasing productivity, reducing cost of production, diversifying cropping in an integrated manner and diverting more of produce for value addition. More focused efforts are required to tackle the issues of low productivity and sustainability, biotic and abiotic stresses, processing and value addition and technology dissemination.

Re-orienting Strategies and Priorities in Research

Harnessing Plant Genetic Resources

India is blessed with rich biodiversity of plant genetic resources. Collection and conservation of PGRs particularly the ones for specific traits and unique ecotypes are important. Excellent gene banks are established for all the plantation crops and enormous opportunities exist to exploit the genetic resources. Evaluation of PGRs for specific traits is essential to harness their potential for crop production. Identification of valuable traits and genes are important to utilize these genetic resources effectively. Registration of germplasm is vital to protect the intellectual property rights of the genetic wealth. In this context, formulation of Distinctiveness, Uniformity and Stability (DUS) guidelines assumes great significance. DUS guidelines have been approved for spices by Plant Variety Protection Authority. There is an urgent need to formulate DUS guidelines for other plantation crops for registration of varieties. Patenting of valuable genes will also enable to

protect the intellectual property rights on the genetic wealth available in the country.

In addition to the utilization of genetic resources for development of high yielding varieties suited to different agro climatic zones, there is need to utilize them in newer avenues. Wild crop species/land races are to be effectively evaluated for biotic and abiotic stress tolerance/resistance. Yield stability in extreme climates such as drought, heat, cold is important in view of the global climate change. Product diversification and biofortification of varieties for greater nutritional benefits such as higher percentage of protein, vitamins etc. are important from the point of view of nutritional security. Search for new genes such as productivity genes for marginal environments could be important for developing varieties suited to such environments.

Application of Biotechnology Tools

In vitro techniques have been standardised for mass multiplication of plantation crops like arecanut, coffee, tea and spices. Embryo culture technique has facilitated safer and quarantined movements of germplasm across nations, especially in coconut. Production of virus free planting material using meristem culture has been made possible in spice crops. *In vitro* germplasm conservation using cryopreservation is of great significance in providing alternative approaches to overcome constraints in management of genetic resources. Molecular markers (RAPD, SSR, AFLP and ISSR) have been utilized for characterizing the extent of genetic diversity in germplasm collections in coconut, oil palm, cocoa, coffee, vanilla etc. QTLs (quantitative trait loci) have been identified for economically important characters in coconut, arecanut, cocoa and oil palm which may aid in marker-assisted selection (MAS) in seedling stage itself (Table 3). It is now possible to detect the plant diseases even before onset of symptoms by molecular diagnostic tools. Many databases and genome analysis tools have been developed in coconut, arecanut, oil palm and cocoa using bioinformatic tools.

Marker Assisted Selection (MAS) as a tool in breeding

Commercial breeding programmes using MAS as a tool in breeding schemes are in progress in several field crops. In most cases, levels of efficiency in selection at early generations and characterization in later generations are the tangible deliverables from MAS. MAS holds great promise for revolutionizing plant breeding, especially in the plantation crops sector and hence, higher priority is to be given to this programme. There is also a need to establish linkages with advanced research institutions.

Table 3. Identification of QTLs in plantation crops

Crop	Markers used	QTLs identified
Rubber	AFLP, Isozyme, RFLP, SSR	Disease resistance
Cocoa	AFLP, Isozyme, RFLP, SSR, RAPD	Disease resistance, Butter Content
Coffee	AFLP, RFLP, SSR, RAPD	Coffee flavour and Transgenic plants obtained Agrobacterium-mediated transformation
Tea	RAPD, AFLP, SSR, ISSR, RFLP	cDNA chalcone synthase (CHS) gene, β -tubulin gene, phenyl ammonia lyase (PAL), caffeine synthetase, primeverosidase genes isolated
Oil palm	AFLP, RFLP, SSR, RAPD	Shell thickness, Yield components
Coconut	AFLP, RFLP, SSR, RAPD, ISSR	Yield components, Mite resistance
Cashew	Isozyme, RFLP, SSR, RAPD	Yield components
Black Pepper	AFLP, RFLP, SSR, RAPD	Disease resistance

Work on MAS is in progress in cocoa, coffee, coconut, black pepper, tea and rubber. Further, for commercialization of the technology, there is a need to develop strong Public – Private Partnership.

DNA finger printing of genetic resources has become important for varietal analysis and inter/intra specific diversity analysis, gene tagging for agriculturally important traits. Constructing DNA genomic library, gene mining, mapping single nucleotide polymorphism, molecular breeding and transgenics are other important areas for future research.

Resource Conservation Technologies

Resource Conservation Technologies (RCTs) provide new paradigm for farming under changing scenario with improved productivity of land and efficiency of water, energy and nutrient use. Minimum disturbance of soil, zero tillage, raised bed planting, maintaining rational soil cover with crop residue/cover crops, spatial and temporal crop sequencing/crop rotations and integration of crop – livestock are important practices in RCTs. Globally 80 million ha of cultivated land are maintained under RTCs. In India, three million ha are covered under RCTs. The average saving due to RCT is calculated to be Rs. 2,500/ha. The impact of RCTs needs to be evaluated in plantation crops too.

Enhancing Nutrient Use Efficiency and Water Productivity

Site specific integrated nutrient management encompassing conjunctive use of organic, inorganic and biofertilizers is the most ideal system to achieve the

highest productivity. Mass movement on vermicomposting, residue recycling and green manuring are to be promoted in a mission mode in each and every village. Geo-referenced soil fertility maps including macro, secondary and micronutrients will enable site specific nutrient management. Augmenting water productivity is important as water is becoming a scarce resource, selection of water efficient crops, adoption of water saving farm practices and need based water supply are the important approaches to achieve higher water productivity.

Paradigm Shift in Soil Fertility Research

The role of soil biota as plant productivity determinant beyond minerals, water and light is now well recognized. Biotic factors assume great significance for managing plantations as self sustainable agro-ecosystems. Promoting soil biology and natural nutrient cycles is considered very important to achieve more sustainable, healthy and productive farming systems. Rhizosphere engineering enables the creation of a biased rhizosphere through addition of specific crop residues and plant specific inter crops – and favour specific microbial communities. Search for phytostimulatory, plant associated culturable microbes enabled the isolation of a revolutionary plant growth promoting culturable endophytic fungus, *Piriformospora indica*. The fungus has broad host spectrum and pronounced growth promotional effects. It mobilises insoluble phosphates and translocates phosphorus to the host in an energy dependent process. As biological hardening agent of micro propagated plants it renders more than ninety percent survival rate in field transplanted plantlets. The association of *Piriformospora* in plantation crops needs critical study.

Liquid Biofertilizer formulations for longer shelf life

Special liquid formulations of desired micro-organisms, nutrients cell protectants, substances encouraging formation of resting spores form the liquid biofertilizers. It has the advantages of long shelf life of two years and zero contamination. Technology has been standardised for production of Nitrogen Fixing Microbes (NFM), Phosphate solubilizing microbes (PSM), Phosphate mobilizing Microbes (PM), Potash Mobilizing Microbes (*Frateruria aurentia*), zinc and sulphur solubilizing bacteria (*Thiobacillus* sp.) and manganese solubilizers (*Pencillium citrinum*).

Organic Farming for Safe Food and Healthy Environment

The ill-effects of chemical inputs used in agriculture to boost productivity is assuming alarming

situations. The high technology mechanized agriculture promoted by high use of agrochemicals caused considerable damage to the natural agro-ecosystem including the very life supporting systems of the earth - the air, water, soil and biota. There is steady depletion of micro-nutrients from the soil, destruction of thousands of fertility improving soil organisms, lowering of water tables to new depths due to excessive discharge of underground water, destruction of contours of land due to mechanical tilling and thus leading to excessive water run off and top soil erosion. Indiscriminate use of pesticides has further destroyed the natural predators and pollinators and other non-target species and increased biological resistance in target pests.

Organic farming has emerged as viable option for sustainable farming. This alternative farming system encourages natural processes, reduces the use of inputs of off farm sources, ensures the long term sustainability and conserves soil, water, energy and farm biodiversity. The input management strategy in organic farming dwells in avoiding or largely excluding the use of systematically compounded chemical fertilizers and pesticides and relying upon crop residues, animal manures, legumes, green manures to maintain soil productivity and supply of plant nutrients. Pest management is achieved through preventive and curative methods including the use of resistant varieties, biocontrol agents and cultural methods.

Plantation crops are highly amenable to organic farming as they produce huge quantities of recyclable biomass which could serve as a rich source of plant nutrients, if recycled through appropriate biological processes. The plantation crops are also endowed with rich diversity of plant beneficial micro-organisms possessing unique beneficial traits. The widely spaced perennial tree crops also provide lot of opportunities for growing diversity of crops in the interspaces for food or commercial purposes, thereby enhancing the biodiversity in the system. Research efforts on organic farming of plantation crops have yielded fruitful results. Central Plantation Crops Research Institute has developed a package of technologies for organic cultivation of coconut.

The present production of organic tea is 3.15 million kg, organic coffee is 370 t and organic spices is 115 t from the country. Increasing demand for safe and healthy food and concern on environmental pollution are the driving forces for the organic movement. The organic sector is showing annual growth rate of 20-25%. It is now recognised that agro-chemical based, high input

agriculture is not sustainable. The technological needs include development of package of practices for organic farming to achieve higher productivity, development of systems with diversified crops and enterprises, quantification of direct and indirect benefits on long term basis and studies on economic viability of organic farming.

Climate Change - a Big Threat to Agriculture

The global atmospheric concentration of green house gases (GHGs) like CO₂, methane, nitrous oxides, CFCs etc., has increased from pre-industrial era. Eleven of the last twelve years rank among the 12 warmest years. Global mean sea level rose at an average rate of 1.8 mm per year over 1961 to 2003. This rate was faster over 1993 to 2003, about 3.1 mm per year. The projected global, mean annual temperature increase by the end of this century is likely to be in the range 2 to 4.5°C or even more. For Indian region, the IPCC has projected 0.5 to 1.2°C rise in temperature by 2020, 0.88 to 3.16°C by 2050 and 1.56 to 5.44°C. Rain fall is likely to increase. Increase in climate variability, droughts, heat waves, hot extremes, cold waves, high wind speeds, heavy rainfall events are likely to become more frequent. Future tropical cyclones will become more intense, with larger peak wind speeds and heavier precipitation. The projected sea level rise by the end of this century is likely to be 0.18 to 0.59 meters. All these considerably effect agricultural production. Plantation crops, being perennials, face bigger challenge from climate change effects. Thus, it is important to have clear understanding on response of plantation crops to elevated CO₂ and temperature. Identification of sensitive stages to climate variability is need of the hour to evolve suitable adaptation strategies. Open Top Chambers (OTCs) provide facilities for Free-Atmospheric CO₂ Enrichment (FACE) and Free Air Temperature Enhancement (FATE). The crop maintained under elevated CO₂ and temperature levels are evaluated for the response in terms of growth, development, yield and quality. Studies on these aspects have been undertaken in coconut, arecanut and cocoa.

Info Crop-Coconut simulation model indicated that under all scenarios of HadCM3 projections, coconut productivity on all India basis is likely to go up by 4% during 2020, upto 10% in 2050 and upto 20% in 2080 over current yields due to climate change. In west coast, yields are projected to increase by up to 10% in 2020, upto 16% in 2050 and upto 39% by 2080 while in east coast yields are projected to decline by upto 2% in 2020, 8% in 2050 and 31% in 2080 scenario over current yields. Yields are projected to go up in Kerala, Maharashtra and

parts of Tamil Nadu and parts of Karnataka while they are projected to decline in Andhra Pradesh, Orissa, Gujarat and parts of Tamil Nadu and parts of Karnataka. However, situations may vary if future irrigation sources are limited particularly in currently irrigated areas such as in Tamil Nadu and Karnataka. The open top chamber (OTC) studies on coconut, arecanut and cocoa seedlings indicated positive response to elevated CO₂. There is a need to do such analysis in other plantation crops as well. For this, it is important to develop crop simulation models such as the one developed for coconut. These approaches help in developing/identifying the suitable adaptation strategies.

Carbon Sequestration and Plantations

To mitigate the GHGs, the two approaches suggested are reduction in GHG emissions and carbon sequestration. Plantation crops offer scope to be carbon sequesters for carbon credit trade. Currently, plantation crops are not covered under Clean Development Mechanism. However, it is important to have the estimates ready in the event of future inclusion. It is only new plantations which qualify for such trade.

New Trends in Disease Management

Diseases continue to be the main production constraint in different plantation crops. Diseases caused by fungi, virus, phytoplasma and bacteria cause considerable yield loss in this group of crops. Integrated approach with focus on biocontrol agents and biodegradable natural products are receiving greater attention in plant disease management. Microbial agents and plant extracts function as elicitors to induce plant defence responses. Elicitors sensitised plants are reported to express more rapid and intense resistance to pathogens. *Trichoderma* and its metabolites (6 penta alpha pyrone) are found to be effective against several soil diseases.

Plant Growth Promoting Bacteria having non auxin pathway

Highly effective plant growth promoting bacteria having non auxin pathway of plant growth/ health promotion have been reported. Recent studies revealed a novel plant health promoting signal mechanism from rhizobacteria. PGPRs release a blend of volatile organic compounds (VOCs) induced growth in *Arabidopsis* and induced resistance against *Erwinia*. Two, three butanediol and acetoin and N – acyl – homoserine lactones (AHLs) are bacterial quorum-sensing signals involved in bacterial cell to cell communication.

Diseases Suppressive Composts

The utilization of organic amendments for control of soil borne plant pathogens is gaining importance as a disease management strategy. Organomineral fertilizers form stable commercial products for application in disease management. Ammonium ligno sulphonates, a by-product from paper and pulp industries have been used as a soil amendment for disease control and soil health management. Development of technologies for effective utilization of lignocellulosic wastes from plantations such as coir pith, coffee husk, and saw dust from rubber wood industries are warranted for use in plantation agriculture.

Strategies for Pest Management in Plantation Crops

Development of bio acoustic detection system for the weevils or beetles damaging the trunk of palms, cashew and coffee is very important. The sensors may be used to collect the sound and vibration caused by the larvae and amplify it.

Host Plant Resistance

Rapid screening of cultivars for assessing their resistance to pests of plantation crops is important. Plant derived compounds are to be screened by monitoring the changes in transcriptome and proteome in insects. Insect anti nutritive or digestive compounds in the cultivars is to be identified and exploited as it would aid to slow the growth of insects. Studies are to be initiated on herbivore induced volatiles. The oral secretion of the insect when comes in contact with plant surface aids to produce defensive compounds and they can be exploited in devising pest management strategy.

Semiochemicals (behaviour modifying chemicals) in Pest Management

Perennial nature of plantation crops invite pests round the year. It is ideal to use pheromone in such ecosystem for monitoring or mass trapping. Emphasis has to be laid to isolate and synthesise pheromone for pests like *Opisina* in coconut, *Helopeltis* in cashew and coffee berry borer. Electrophysiology techniques can be employed in identifying the compounds that elicit response in insects in plantation crops. CPCRI has taken a lead on this line and established a electrophysiology laboratory. Studies can be initiated on the herbivore induced signaling in crops. Damaged plants emit bouquet of volatiles that either deter their conspecifics from egg laying on damaged plants or deter the larvae from feeding on damaged plants. The volatiles, if identified, can be used to deter the pest. The volatiles that are responsible for attracting the ovipositing adult can be exploited to

trap the female adults. Transgenic plants can be developed by silencing the gene that emit volatiles that attract the pest to plants. The damaged plants emit volatiles that attract the parasitoids and this can be used to enhance the efficacy of the parasitoids.

Upscaling Biological Control Programmes

Emphasis is to be laid to formulate or mass multiply the bioagents. Timely availability and quality control of the bioagents supplied to farmers are to be emphasized to install confidence on the use of bioagents. Mass production of bioagents is to be mechanized so that the production can be enhanced during out breaks. The efficacy of the parasitoids can be enhanced by olfactory conditioning. Olfactory learning by *Goniozus nephantidis* enhanced the host searching ability. CPCRI has developed technique to condition the parasitoids.

Biotechnological Approaches

Selection of parasitoids and predators with resistance to pesticides and environment hardiness increases fecundity. In case of entomopathogenic fungal strains that have protease for better cuticle penetration in insects are identified. The efficacy of the baculovirus can be enhanced by engineering the insecticidal proteins so as to bring quicker kill of the insect.

Quarantine measures

In today's era of globalization, the risk of introduced pest is increasing (eg. Coconut hispid, *Brontispa longissima* and coffee berry borer). Pests and diseases that escape the early detection can establish and cause damage to agricultural resources (Eriophyid mite and slug caterpillar) and hence, this demands strengthening of the quarantine and surveillance measures. Early detection minimizes the crop loss and results in abundant and affordable supply of food. Creation of a detailed database on pest incidence in plantation crops can help in preparation of prediction models.

Value added Diversified Product Development

The future of plantation crop industry depends to a great extent on its competitive ability to produce diversified value added products at competitive rates without sacrificing the quality. Changing food consumption pattern and income elasticity of world community also underlines the need for accelerated value addition. The demand supply balance is also in favour of enhanced value addition to meet the ever increasing demand for value added products. Shifting agricultural

resources to high value options is warranted for achieving competitiveness. Farm level processing in village community level should be encouraged to overcome the problems of fragmented holdings. Quality standards meeting international standards need to be developed for achieving competitiveness in international trade.

Plantation based Agribusiness

Plantation crops are prone to high degree of production and price risks. Due to increase in consumer awareness, the domestic demand for value added coconut products is expected to increase in medium to long run especially in developing countries. Agribusiness entrepreneurs can capitalize this situation for small/medium/large scale production and marketing of plantation based value added products(Fig. 2).

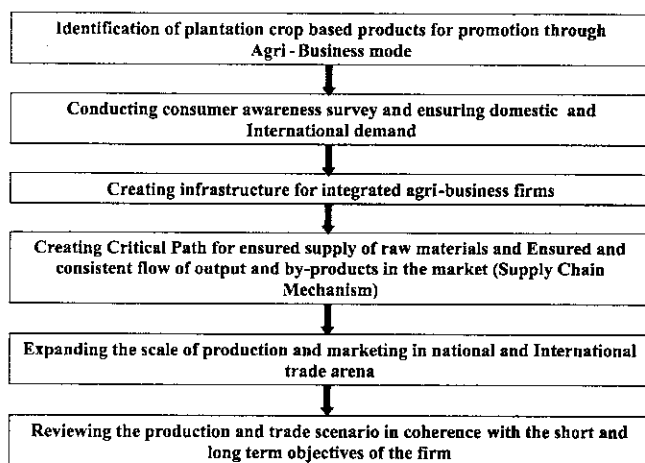


Fig. 2. Plantation crop based agribusiness model

Agribusiness and its management on a mission mode approach aims at maximization of farmers' farm income with sustainability. Though India is one among the largest producers of certain plantation crop based products in the world, its relative share in the international trade arena is less significant as compared to other major producing countries such as the Philippines, Indonesia, Brazil, Guatemala, Papua New Guinea, 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 various plantation crop based products such as virgin coconut oil, snow ball tender nut, coconut chips, copra, vinegar, desiccated coconut, coconut shell powder, coconut shell charcoal, packed tender nut water, coconut cream, coconut milk powder, cocoa butter, natural dyes and adhesives from arecanut, premium coffee and tea, pepper and cardamom based products etc.

Using the processing technologies of plantation crop based products, economically viable processing units are to be established preferably through scientific integration. For this the Government of India needs to formulate a major project at macro level involving huge budget. State Governments assistance and attention is also needed as in India agriculture remains as a state government subject. Research and Development agencies needs to strive for achieving sustainable growth in coconut production and productivity. Market surveys need to be taken up both in India and abroad for assessing the nature and quantum of demand for value added coconut products.

The existing value added technologies need to be tested for getting credibility about their technical feasibility and economic viability especially as an integrated system. Quality parameters especially with reference to ISO standards need to be studied and based on that the budget revision needs to be made for project implementation. Suitable locations in various agro-production zones may be identified. More number of pilot plants may be started and their techno-economic viability studied. An intensive market promotion is a must for creating consumer awareness about the products. A strong will and commitment is a pre-requisite for achieving success in this endeavour. It is difficult but not impossible.

Technology Delivery System – Group Extension Approaches

Technology dissemination among the farming community is one of the key issues in the plantation sector. The technology transfer should be farmer centered for easy dissemination. Group approaches assume significance particularly in the case of small holders' plantation crops to overcome the problems of small scale of operations. Establishment of Community Based Organisations (CBOs) and providing village level micro-credit systems were found to be effective strategies for dissemination and successful adoption of income generating technologies by resource poor coconut farmers. Farmer Field Schools (FFS) can also be an effective extension strategy for technology intervention and dissemination through the involvement of research institutes, master trainers and extension agencies. A contiguous area or compatible group of farmers including women, who are willing to participate can be selected for an FFS site. The major activities include a benchmark

survey, formation of FFS, capacity building, field visit, agro-ecosystem analysis and group dynamics exercises. Clustering of farmers is another group approach to implement the interventions at community level to bring about perceptible change in production, productivity, employment and income of the people involved. Cluster approach consists of Participatory Rural Appraisal, Cluster initiation and Management, Implementation of Interventions, Entrepreneurship development and Triangulations/linkages. The group extension activities can form a successful approach for technology delivery to achieve better livelihood of small and marginal farmers.

Research-Extension-Farmer Interface facilitated through Cyber Extension Programmes

Cyber Extension includes effective use of information and communication technology (ICT), national and international information networks, internet expert systems, multimedia learning systems and computer based training systems to improve information access to the farmers, extension workers, researchers and extension managers. Video conferencing technology has also emerged as an effective tool to facilitate interaction between various stakeholders.

Conclusion

Plantation crop sector had a glorious past and tremendous future to provide livelihood and income for millions who depend on these group of crops by way of cultivation, processing, marketing and trade. There is overwhelming evidence that India had competitive advantage in export of plantation commodities. In the present era of globalization and liberalization of trade and in the context of new and formidable challenges faced by the crops in terms of climate change, biotic and abiotic stresses and environmental concerns, a reorientation of strategies and research approaches becomes imminent. Capacity building of researchers is vital to build up a competent human resource to address the new challenges. Networking of researchers at various levels and collaborations in different segments and co-ordination between the agencies will greatly help to improve the system to harness the potentials in the most effective way. Intensive research and developmental efforts and innovative approaches are required to maintain our leadership in production and to get appreciable share in international trade.