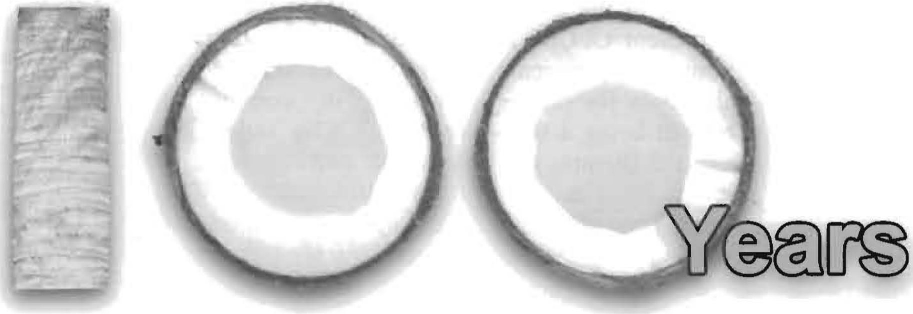
Path of Glory



of Coconut Research in India

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Introduction

The evolution of coconut research in India has its roots in the culture, identity and lives of many. The research aspects of coconut can never be viewed as a unilateral component because of the essential social-embeddedness the sector is sharing. It is an indubitable fact that the coconut sector in the country, over the last 100 years had experienced tough times, moments of pride, moments of tears as well as excellence in research and development. The striking feature of the sector is that, it has come out much stronger edging out the adverse periods. The contribution of research facet to the sector is invaluable. As an accepted fact, the research on long duration plantation crops like coconut is always tough, and many a times comes under severe criticism. Having this in mind, the efforts in the research front of coconut is indeed worth adulation. Since the coconut research in the country reached the 100th year, it is the right time to have retrospection on the journey of coconut research in the country.

Setting up the premises: an earlier period

In accordance to the report of the Famine Commission 1901, the Imperial Government of India sets up a Central Department of Agriculture and agriculture departments in the provinces to primarily look after agricultural enquiry, agricultural development and famine relief in the country. However, it was only after 1905 that with the reorganization of the agriculture department, agriculture research was organized on a more systematic line,realizing the need to explore and develop further income resources from agriculture and for sourcing raw materials for the industrial England on a long term basis.In consideration of the unlimited opportunities that the vast and agro-ecologically diverse empire offered,agricultural experimental stations were started in the most important agricultural tracts.In line with this development, three separate blocks of vacant land in and around the village of Nileshwar (Nileshwar I (Pilicode), 15 acres), Nileshwar II (20 acres), Nileshwar III (20 acres) and an existing coconut garden in Kudlu Village (26 acres) (all in the present day Kasaragod district of Kerala state, India) were acquired in order to obtain representative soils, on which coconuts were generally cultivated on the West Coast and thus four sub-stations have now been started in the South Kanara district of erstwhile Madras Presidency.

Initiating the scientific research: The beginning

The three blocks out of the four acquired for coconut research were vacant lands and naturally it takes several years for the well-laid experimental plots to be available for laying out new experiments, the standing coconut crop (though not scientifically planted) in the newly acquired Kudlu block (where the present CPCRI is located) was used for initiating preliminary experiments as a trial-run for collecting valuable data for proper planning of future experiments.Coconut being a crop fairly unfamiliar to western science, initial attempts was to study the morphology of the palm, its floral biology, manurial operations and cultural practices, introduction of varieties etc. By all records, probably this must be the earliest case of organized systematic research on coconut the world over.

One can see the blueprints in these early experiments, on which systematic investigations were conducted in later years. The early observations of palm-to-palm variation in growth and yield, and enumeration of yield contributing characters have led to the concept of pre-potent palms and careful selection of such superior individuals in a population has given most promising rewards in later years. The investigations on crown morphology elucidating the right hand spiral and left hand spiral arrangement of leaf whorls and the classical study on the coconut root system and its feeding area are phenomenal. The need for collecting good seed nuts from select palms and selecting good seedlings at nursery stage based on a set of criteria especially the split leaf were emphasized as early as 1918. A series of manurial experiments were started to understand the nutritional requirements, the absorption pattern and the optimum methods of supplying them. The benefits of growing green manure crops and soil moisture conservation by mulching were recognized in the early years.

Pioneering the coconut demonstration plots

Laying out demonstration plots in research stations and farmer gardens as a way of demonstrating and convincing farmers to adopt technologies had always been a key extension strategy. Strikingly, the Annual Report of the Coconut Stations in Kasaragod as early as in the year 1921 reported the advantages of intercultivation. The Annual Report (1923-24) states "the ryots having realized the superiority of our seedlings are coming forward with their applications not only from the West Coast districts, but also from other parts of the Presidency". "There has been a considerable awakening in the South Kanara district to the possibilities of coconut types. When the coconut trees were once established, it was the practice to give no further attention to them. The methods adopted at the Kasaragod station, where a large increase in crops has resulted from after treatment, have led to considerable interest and imitation and the district staff stationed in this district have done all in their power to bring our improved methods to the notice of the cultivators" . This evidence clearly highlight the wisdom of the earlier committed workers in coconut research, who indeed initiated cutting edge transfer of technology techniques in those times.

Dr. J.S. Patel

The first coconut hybrid: A land mark

The development of hybrid varieties involving tall and dwarf types possessing prolificity and precocity is a major landmark in the annals of coconut improvement. It was the pioneering work of Dr. J.S. Patel and his team that paved the way for the exploitation of heterosis in coconut. The first hybrid was produced by crossing local West Coast Tall with the Chowghat Dwarf Green and the hybrids were planted at Nileshwar in 1934 for evaluation. Since then, six coconut hybrids have been developed/ released from CPCRI, a mammoth achievement in itself, considering that developing and evaluating a new hybrid in a perennial crop like coconut takes about two decades. The demand for hybrid seedlings of coconut have ever been on the increase and now large scale production programmes are in progress to meet the increasing demand.

Central Plantation Crops Research Institute, Kasaragod

Phase of Transition: Indian Coconut Committee

Coconut research had been the responsibility of only the State Departments of Agriculture until 1945, when the Indian Central Coconut Committee (ICCC) was constituted to coordinate research and development activities at the national level. The committee took over the Kasaragod (Kudlu) research centre and developed it in to the CCRS, Kasaragod and the other three field stations remained with state department of agriculture and later handed over to Kerala Agricultural University in 1972. The Central Coconut Research Station (CCRS) at Kayamkulam was established in 1948 by the Indian Central Coconut Committee.

During the first phase, at CCRS Kasaragod, the area was increased to 100 acres by acquiring additional land. Research was reorganized under four disciplines, namely agronomy, botany, cytogenetics and analytical chemistry. The next phase of development of CCRS began in 1958 with the implementation of the Second Five Year Plan. By early 1960, the activities of the Institute expanded and the staff strength increased along with other infrastructural facilities. During this period, the main thrust was on survey and identification of indigenous germplasm, laying out of large-scale fertilizer trials, crop weather studies, survey of coconut soils of Kerala, cytological and anatomical studies, studies on button shedding and barren nut formation, preliminary studies on irrigation, lime requirement in coconut soils, seednut storage, etc. The achievements made by the CCRS with the minimum basic facilities and manpower available are stupendous. The significant contributions made towards gathering basic knowledge about the palm and the vast data collected in those days still form the basis of current research programmes.

Institutionalizing the research

The Indian Council of Agricultural Research (ICAR) took over the administrative control of CCRS at Kasaragod and Kayangulam from 1st April, 1966 following the abolition of the Commodity Committees. Since then, it was felt that the CCRS cannot exist by itself at an all India level, the then Director-General, late Dr. B.P. Pal, F.R.S. and the Secretary, ICAR, Dr. K.P.A. Menon visited the CCRS Kasaragod and CARS Vittal and discussed the pros and cons of amalgamating these two Stations along with the Research Centres of CARS into an All India Research Institute for the agricultural plantation crops (excluding tea, coffee and rubber). Thus, the Central Plantation Crops Research Institute (CPCRI) came into existence in January, 1970. The Central Arecanut Research Station (CARS)Vittal along with the five substations under the Indian Central Arecanut Committee was also merged with the new entity. With the establishment of Central Plantation Crops Research Institute (CPCRI) in 1970 at Kasaragod, the CCRS Kayamkulam and CARS, Vittal were designated as regional stations.

Subsequently, the administrative control of the two ICAR Research Complexes in Goa and Lakshadweep were also transferred to CPCRI in 1976. A scheme for initiating research on spices was sanctioned by ICAR

Kalpajyothi

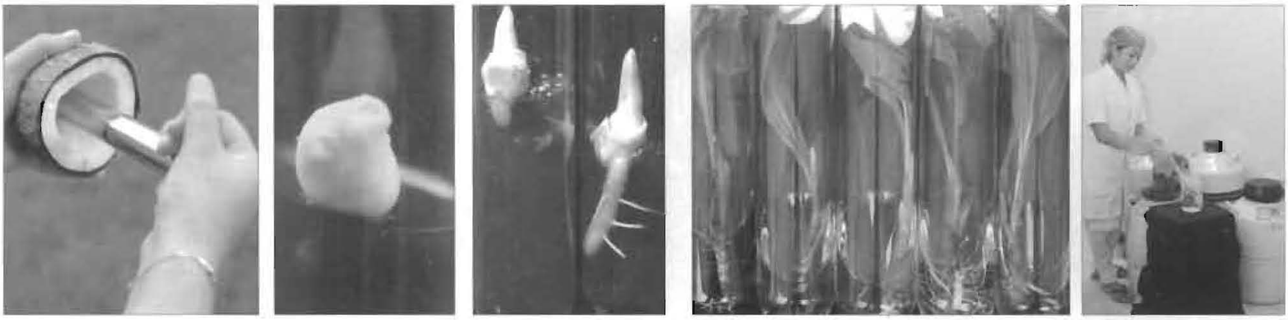
Kalparaksha

Chowghat Orange Dwarf

during the Fifth Five Year Plan and CPCRI set up a new Regional Station at Calicut in 1975 with the laboratories at Chelavoor and the farm at Penivannamuzhi for conducting research on pepper, ginger, turmeric, clove, cinnamon, nutmeg, allspice and vanilla. It was thus entrusted with the responsibility to co-ordinate the research efforts in all important plantation crops like arecanut, oil palm, cashew, cocoa, cardamom, pepper and other spices, besides coconut.The All India Co-ordinated Coconut and Arecanut Improvement Project and Cashewnut and Spices Improvement Project came into operation with effect from 1-10-1970 and 2-12.1970 respectively.The network was further strengthened in the later years. The AICRP on Palms has at present 15 centres on coconut, four on arecanut, eight on oil palm and two on palmyrah, covering the important cropping tracts.

Indian Society for Plantation Crops:A meaningful agglomeration

With the establishment of Central Plantation Crops Research Institute in 1970, the scattered and isolated units carrying out researches on individual plantation crops were brought together under a single agency of ICAR, with the possible exception of coffee, rubber and tea (for which separate research institutions were already there in place). Consequent to the inception of the Institute, it was felt that a common forum be established to bring together all scientists working on these crops so as to facilitate free exchange of ideas and experiences. The Indian Society for Plantation Crops (ISPC), a professional forum devoted to sustainable growth and development of plantation crops sector, was thus established in 1971 with headquarters at Kasaragod and this society has presently metamorphosed into one of the premier scientific societies in India. Its main activities are publication of the Scientific Journal, Journal of Plantation Crops (JPC), holding National and International Symposia (PLACROSYM) and encouraging original research by instituting various awards.The forum for scientific communication in the sector was initiated through the Journal of Plantation Crops (JPC), as a multidisciplinary journal, aims at dissemination of research findings in plantation crops (coconut, arecanut, cocoa, cashew, oil palm, coffee, tea, rubber, date palm), including cropping systems, as well as various spices. Since its inception in 1973, 42 volumes have been published. The journal is published thrice a year during April, August and December and



Plantlets from Embryo culture Cryopreservation of embryos and pollen

publication of the articles is subject to peer reviewing and recommendation by experts in the field.

Garnering the germplasm: Way back in 1981

Survey and collection of coconut germplasm in Pacific Ocean territories was undertaken in 1981 with the financial assistance from IBPGR/FAO. A scientific team was deputed to Solomon Islands, Fiji, American Samoa, Western Samoa, Tonga and French Polynesia and they collected 2500 nuts from 23 sites from these countries. The collection consisted of 20 Tall types and four Dwarfs. These include types known in the literature as 'Rennel Tall', 'Solomon Tall', 'Fiji Tall', 'Samoa Tall', 'Tahiti Tall', 'Rangiroa Tall' and 'Dwarf Yellow' (American Samoa) 'Dwarf Orange' ('Rangiroa', also known as 'Hari Papua') and 'Niuleka' (Dwarf Fiji). Two tall types, 'Bulundrau' (Fiji) and 'Takovs' (Tonga) having large number of small nuts (comparable to 'Laccadive Micro' of India) was also collected. These collections were initially planted at the newly established World Coconut Germplasm Centre in Andamans and subsequently most promising selections from the original collections were relocated to the ICG-SA at the CPCRI Research Centre, Kidu in Karnataka.

Though coconut germplasm was introduced in India from south and south east Asia several times in the past as early as 1924, this is the first case of a scientific exploration mission to outside India. This mission to the region considered to be the 'original home of coconut' has turned out to be highly rewarding, as these precious collections were the foundation material from which several new hybrids/selections were developed / released in recent times and still more are in the testing line.

Strategic Breeding: Focus on dwarf hybrids

Early attempts were at developing tall varieties and T x D hybrids considering their higher yield potential and oil percentage, hardiness and adaptability to varied climatic and edaphic conditions. Of the nineteen coconut varieties and hybrids developed by CPCRI so far, nine of them are either tall or T x D hybrids.Now, in the present scenario of acute shortage of palm climbers and the increasing demand for tender nuts and also neera tapping, there is a rethinking in the breeding strategies, with the emphasis now placed on developing dwarf varieties and D x T hybrids suitable for tender nut and also dual purpose (conventional copra/oil and tender nut purpose). Apart from the Chowghat Orange Dwarf released in 1991, the recently developed varieties like Kalpa Surya and Kalpa Jyothi (as exclusive tender nut varieties), are a welcome step in this direction. Incidentally, the ICAR-CIARI, Port Blair has recently released four dwarf selections (Annaporna for copra purpose, Chandan, Surya and Omkar for ornamental and tender nut purposes)from the exotic germplasm of Pacific region conserved by CPCRI at the erstwhile WCGC, Port Blair (now under ICAR-CIARI).

Another facet of the present breeding strategy is to look for other desirable traits like suitability for value addition

Plantlets regenrated from plumule

Coconut based cropping system integrating with black pepper, banana, tubers and vegetables

and/or biotic and abiotic stress tolerance, apart from the traditional emphasis on yield potential. Kalpa Pratibha, Kerachandra and KalpaHaritha are recommended as dual purpose varieties suited for both copra and tender nut purpose. Kalpatharu is recommended as a ball copra variety, owing to minimal spoilage and higher recovery percentage of ball copra. The varieties, Chandra Kalpa, KalpaMitra, KalpaDhenu, KeraKeralam and Kalpatharu are also relatively tolerant to drought. Kalparaksha and Kalpasree are recommended for root (wilt) affected tracts as disease tolerant varieties.

Clonal propagation is still issue although success met with embryo culture, cryo preservation and hybrid authentication

Tissue culture of coconut was initiated in 1977 at CPCRI. Although coconut plantlets have been regenerated and successfully established in the field, a commercial scale protocol has not been achieved and conversion of somatic embryos into plantlets has remained as one of the major bottlenecks.Due to recalcitrant nature and bulkiness of seeds, the collection of coconut germplasm from far off places is difficult and costly. A successful protocol has been developed for efficient in vitro culturing of coconut embryos and plantlet regeneration.

Cryopreservation techniques have been standardized for mature coconut zygotic embryos and pollen. Since coconut is a perennial crop, which takes longer periods for stabilized yield, the quality of the planting material is significant for the successful cultivation. Morphological markers such as germination rate and colour of the petioles are used in selecting hybrid seedlings in the nursery.

Morphological marker based screening often lead to confusion since many cultivars have similar characteristics. RAPD (Randomly Amplified Polymorphic DNA) marker technology has been developed to identify hybrids at nursery stage. The genetic homology of the bulbils from two coconuts growing at CPCRI, Vittal through microsatellite analysis have demonstrated that the use of both primary and secondary bulbil shoots as propagules for producing viable clonal progeny of bulbil-producing palms. If we could get bulbil-shoots induced in our Super Palms too, by 'shooting' with a 'Gene-gun', to activate these 'bulbil-inducing genes'. The "Pollen Gun", with which one can 'shoot' Coconut Pollen from ground level, to pollinate the emasculated spadices located 40 to 50 feet above has been developed.

The wisdom of cropping system approach

Coconut based cropping systems, initially conceptualized and developed in the eighties and further refined in the succeeding years, is a highly versatile, sustainable, profitable system, optimizing the use of available resources. Different models tailor-made for various agro-ecological zones and suiting different requirements of households have also been evolved over the years. The advantage is that you can select the component crops, based on the food preferences and nutritional requirements of the family and optimum income possibilities considering the prevailing market realities. By the latest estimates, a coconut based cropping system using multi species cropping of coconut with pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income of Rs 3.7 lakhs per ha, which is 150% higher than that of coconut monocrop (Rs 1.4 lakhs).

Multi species cropping system has further evolved in to mixed farming system by integrating livestock enterprises in to it. It is a classic case of the society demanding it and the research institution answering the distress call. Of late, the coconut growers are exposed to economic risks and uncertainties owing to the frequent price fluctuations for the produce. In this context, it is needless to emphasize the importance of crop/ enterprise diversification in coconut gardens.

Coconut based integrated farming system integrating dairy, goats, poultry and aquaculturen and production of biogas

Drip fertigation, mulching with coconut husk and bund reinforced with pineapple planting

The research at CPCRI clearly indicated the scope for integration of crops and animals in the coconut garden for enhancing income and providing employment throughout the year. The system, thus developed, is a closed one, requiring less farm inputs and gives importance to recycling of produces/ wastes among the components in the system. It facilitates high input use efficiency and energy-efficient practices through proper linking/integration of different components and intelligent management of available resources. Besides enhancing coconut yield, there was substantial improvement in soil and plant health status, soil physical properties and soil biology, thereby making CBIFS more economically feasible and ecologically sustainable. Added attraction is that subsidiary income is also realized from all the component units. As per the recent investigations, a coconut based mixed farming system (CMFS) comprising coconut, pepper, banana, fodder grass, crossbred cows, poultry birds, goat, and pisciculture generated a net return of Rs 5.5 lakhs, which is 288% higher than that of coconut monocrop.

Plant growth promoting rhizobacteria: New paradigm

Plant growth promoting rhizobacteria (PGPRs) are now being considered as new microbial resources for enhancing crop productivity. They are known to possess multiple plant growth promotion and systemic disease resistance induction properties. Bacillus megaterium isolated from coconut rhizosphere has been released under the brand name 'KeraProbio' for production of healthy and vigorous seedlings of coconut. Its inoculation has shown to give 30-38 % increase in total dry matter of coconut seedlings.

Per drop and more crop

Drip fertigation reduced the use of chemical fertilizer from 50 to 75 per cent with increase in yield by 35-40 per cent. Bund reinforced with pineapple planting and providing catch pits could enhance coconut yield upto 60%.Trench and mulching with coconut husk conserve the soil moisture and improves the yield considerably.

Converting wastes into wealth

About 6-8 tonnes leaf wastes is produced annually from per hectare coconut garden.As much as 4000 kg of good quality vermicompost can be produced from the wastes generated from 1 ha of coconut garden every year using African Night Crawler (Eudriluseugeniae). It converts coconut leaves into vermicompost in less than three months period and compost has C: N ratio of 10-17, 1.8 to 2.1 % N, 0.21 to 0.3 % P and 0.16 to 0.4 % K and organic carbon content of 18-20.

The vermicompost produced from coconut leaves using the technology developed at ICAR-CPCRI is now available by the trade name 'Kalpa Organic gold'. Fresh coconut leaf vermiwash is alkaline and contains major

Vermicompost from coconut organic wastes

Recylcing of organic wastes: vermicompost, vermiwash and composted coir pith

and minor nutrients, growth hormones, humic acid and plant beneficial bacteria. Coconut leaf vermiwash acts as a plant growth stimulator. A simple technology has been developed at ICAR-CPCRI for conversion of coir pith having a C:N ratio of 100:1 to acceptable manure that does not involve addition of urea. The coir-pith compost produced by ICAR-CPCRI technology is light weight, dark coloured porous product with pH in the range of 6.1 to 6.9 and having up to 500% water holding capacity. The N, P and K content ranges between 1.3 to 1.4, 0.9 to 1.2 and 1.3 to 1.6 %, respectively, and is a good source of micronutrients as well. The coir-pith compost produced using the technology developed at ICAR-CPCRI has been released by the trade name 'Kalpa Soil Care'

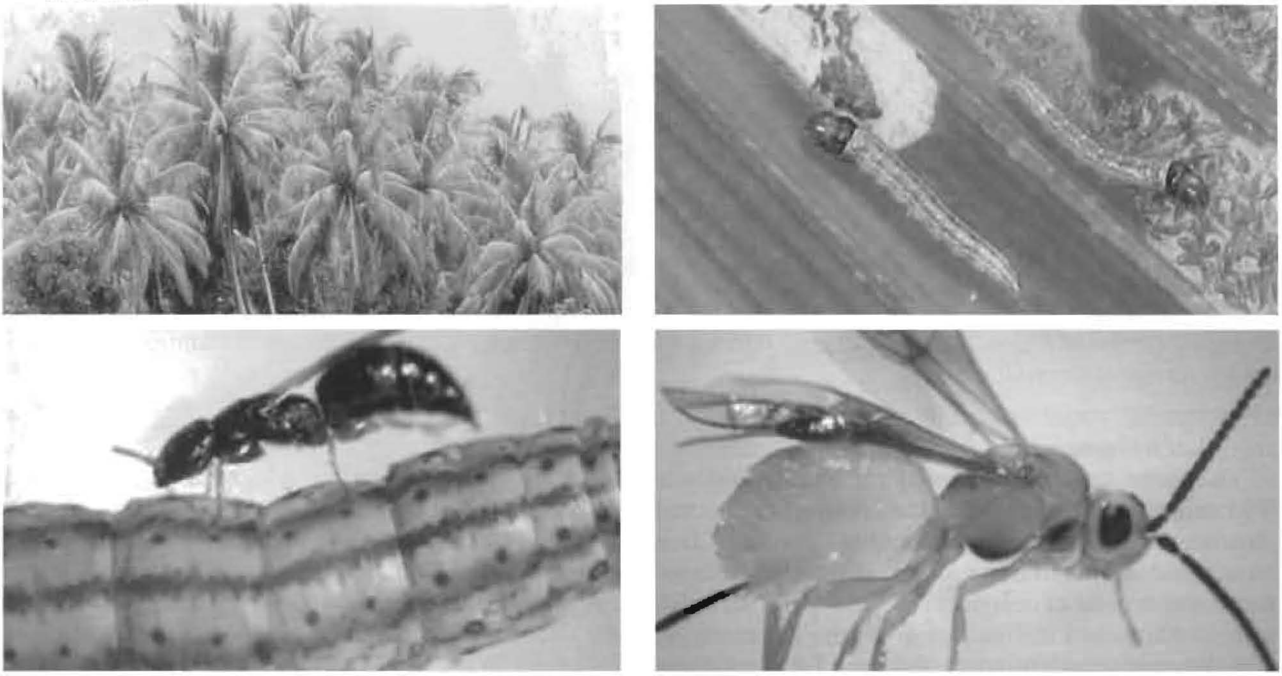
Biochar is a charred solid material obtained from thermochemical conversion of plant derived biomass in an oxygen limited environment. Attempts have been made to produce biochar from coir pith and immature coconut (tender nut) husk, a waste produced from coir industries and tender nut parlours, respectively, using a charring kiln.

Coconut by-products such as leafstalk, bunch waste, leaflets has been successfully utilized for production of oyster mushroom (Pleurotusflorida), Wastes generated from 1 ha area of coconut can yield about 1700 kg of fresh mushrooms. The spent mushroom substrate obtained after mushroom cultivation can be used to produce compost/ vermicompost for use as soil organic amendment

Root (Wilt) Disease: The breakthrough

A breakthrough in the etiology of root (wilt) disease of coconut was accomplished in the 1980s. Through systematic research, the involvement of fungi, bacteria, virus, viroid, nematodes and soil factors in the incidence of the disease was already ruled out. Mycoplasma Like Organisms (MLOs) were detected under electron microscope in ultra thin sections of developing leaves, unopened inflorescences, root tips, and terminal bud tissues (in the sieve tubes of phloem) in coconut root (wilt) affected palms and were conspicuously absent in samples from healthy palms. No virus-like particles or microorganisms other than MLOs were made out in these ultra thin preparations. Sample preparations and ultra microtomy were performed at the CPCRI Regional Station, Kayangulam and ultra thin sections were examined under electron microscopes at the Christian Medical College, Vellore, the Cotton Technological Research Laboratory, Bombay and the Institute for Plant Diseases, Bonn, West Germany, where the presence of MLOs was observed in disease affected palms.

The scientific advancements in later years have resulted in redesignation of these 'sub-microscopic non-culturable vascular limited plant pathogenic organisms' more specifically as Phytoplasma, and not MLOs. Successful transmission of the disease by lace bug (Stephanitistypica) and plant hopper (Proutistamoesta) under insect-proof conditions has further established the phytoplasmal etiology. With the advent of polymerase chain reaction (PCR) based detection techniques, molecular characterization in recent years have established the coconut RWD Phytoplasma as belonging to the 16srDNA XI group. Besides, a sensitive, simple and rapid sero-diagnostic test was also developed by the institute to detect the phytoplasma even 6-24 months prior to the expression of visual symptoms.Fortunately, root (wilt) disease of coconut is only a debilitating disease and not a lethal one and as such the health, and yield of palms can be improved/maintained through the adoption of integrated management practices consisting of balanced fertilizers, addition of organic matter, raising green manure crops in the basin and its incorporation,



Black headed caterpillar (Opisinaarenosella) infested coconut and parasitoidsBraconbrevicornis and Goniozus-nephantidis

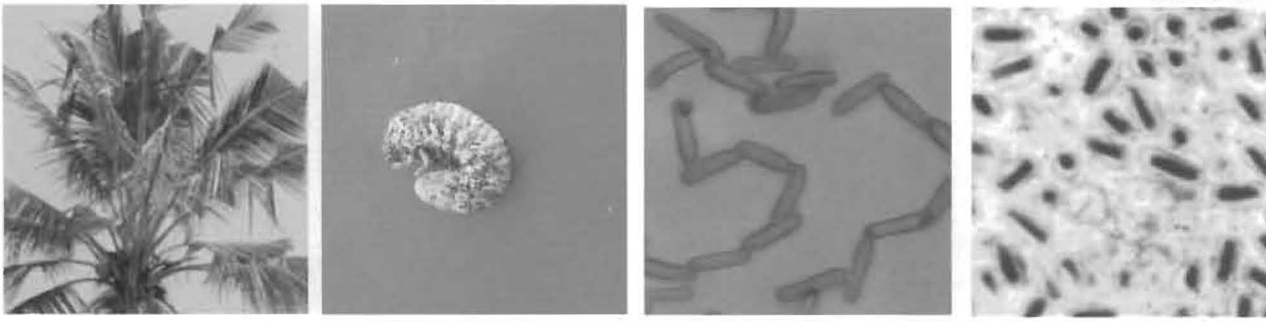
weed control, leaf rot control and recycling organic matter. In general, apparently healthy palms and those in the early stage of disease respond better to management practices.For ensuring better economic returns and for a sustainable family farming, farmers are encouraged to adopt integrated cropping/farming systems.

Biological control: A land mark in pest management

Plant protection in India, and for that matter most of the developing countries in general, was mainly based on the use of chemical pesticides. Chemical control is, of course, one of the effective and quicker method in reducing pest population, where farmer gets spectacular result within a short time. However, over reliance and indiscriminate use of pesticides resulted in a series of problems in the agricultural ecosystem mainly, the development of resistance to insecticides, pest resurgence, outbreak of secondary pests into primary nature, environmental contamination and residue hazards, destruction of natural enemies of insect pests etc. All these problems contributed to developing a new way of pest control, i.e. the integrated approach of pest control. "Integrated Pest Management is an ecological approach in which utilization of all available techniques of pest control to reduce and maintain the pest population at levels below economic injury level". Though Integrated Pest Management (the term IPM was introduced by R.F. Smith and R. van den Bosch in 1967) was adopted as a policy by various world governments during the 70's and 80's, including the USA in 1972, India declared IPM as official policy only in 1985.

The importance of pest control in crop husbandry was recognized in the early days itself and initial investigations were on developing chemical control regimens for major pests of coconut. Concurrently, investigations were intensified for exploring natural enemies and standardizing their mass production and release in the field. Biological control of the coconut caterpillar,Opisinaarenosella Walker, with the indigenous larval/pupal parasitoids like Braconbevicornis and Goniozus nephantidis became a reality in the 1980s itself.

Though the infection of O. rhinoceros by virus (OrV) was first reported in Malaysia in 1966, a detailed work on it was done in India only in 1983. The population of O. rhinoceros and its damage on coconut palm was checked substantially when the OrV was released/re-released in Minicoy and Androth islands of Lakshadweep, Chittilappillly in Trichur, Kerala, and Sipighat of Andaman Islands. Thus, the success encountered by the use of this microbial pathogen has endorsed its claim as one of the landmark examples in the biological control of an insect pest. M. anisopliae, commonly termed as the 'green muscardine fungus' (GMF), is a well-known entomopathogen. The susceptibility of O. rhinoceros to it was first reported in Western Samoa in 1913 and in India in 1955. M. anisopliae var. major (spore size 10-14 μm) is a highly infective strain used widely for the



Biological control of Rhinoceros beetle a) grub infected with Metarhiziumanisopliae b)Metarhiziumanisopliae spores c) Oryctes rhinocerosnudi virus

control of this pest.

Over time, the classical bio-control has evolved in to IPM, incorporating elements of bio-control, minimal and judicious use of pesticides and cultural practices. It is most gratifying that IPM packages have been developed for all major pests of coconut. The beauty of IPM is that it is not static and it should evolve with the changing pest dynamics, underpinning the need for continuous evaluation and refinement. Presently, efforts are on to develop greener safer molecules as alternatives to many of the chemicals widely used at present,bio-pesticides and bio-agents, with minimum health risk for humans and other living organisms and ensuring a safe and clean environment at large.

Opening up new vista: Semiochemicals in Integrated Pest Management

Deciphering the 'chemical code' of insect communication has revolutionized the science of pest management. Semiochemicals, the signalling molecules used in insect-insect or plant-insect interaction, are now increasingly considered within IPM strategies as an alternative or complementary approach to insecticide treatments. Semiochemicals can be either allelochemicals or pheromones, depending on whether the interactions are interspecific or intraspecific. Pheromones are perhaps the most widely exploited semiochemicals at present, but recent efforts are also directed at identification and use of compounds involved in interspecific interaction as well, especially other behavior-modifying semiochemicals like host plant volatiles (which work either as attractants or repellants). Enormous work is involved in developing an efficient system, which involves identifying and optimizing pheromone blends, best dispenser dosages and fine-tuning trap designs to ensure that they are highly species-specific and optimally attractive to the target species.

The pheromones have been widely used for monitoring adult populations of endemic pest species, detection and survey programs for invasive species, mating disruption, and mass trapping of target species. The technique of mass trapping using pheromones has become a highly effective, environment-friendly and relatively inexpensive means of suppressing populations of those pest species whose pheromone communication systems and bionomical characteristics make them susceptible to this approach. In this technique, traps are deployed at optimum densities that have proven to attract and capture sufficiently large numbers of insects ensuring direct reduction in damage to the crop. In coconut IPM, the basic strategy employed is mass trapping of adult insects using pheromones. There are several reports of highly successful and effective commercial mass-trapping programmes being executed against weevil pests of coconut and other palm species like oil palm, especially the American palm weevil (Rhynchophoruspalmarum), a highly damaging pest of oil and coconut palms in Central and South America, red palm weevil (R. ferrugineus) infesting oil palm and coconut in the Middle East and coconut rhinoceros beetle (Oryctes rhinoceros) in the Middle East.

Because of the complex biological activity of semiochemicals, their dispersion in the ecosystem need to be regulated carefully, which warrants development of slow-release devices ensuring a controlled release of these biologically active volatile compounds, from both biological and economic considerations. In India, aggregation pheromone (4 methyl 5 nonanol +4 methyl 5 nonanone 9:1) is used in tandem with food baits to attract the red palm weevils. Though effective, these lures need to be replaced once in 3-4 months. Nanoporous materials are a novel carrier/ dispenser for the volatile signaling molecules with controlled spatiotemporal release rates. A nano-dispenser, with ordered pore channels, has been developed for loading the pheromone and kairomone blends of red palm weevil, ensuring a delayed dissipation (as confirmed by Field Scanning Electron Microscopy (FESEM), X-ray Diffraction (XRD) and Thermal Gravity Analysis) and consequently longer life in the field.

CPCRI has recently successfully characterized the

Cocosap chiller to collect Kalaparasa

kairomones (allelochemicals emitted from the host attracting the insects towards it) from host volatiles, which can act as pheromone synergists in red palm weevil management.Placing of food baits (fermenting banana, pineapple and neera) with the commercially available pheromone lure in the conventional bucket trap was found to have synergistic effect in attracting the red palm weevils. It was then reasoned that, if the volatiles released from these food baits are identified, it can facilitate development of efficient kairomones that could be used in tandem with pheromone, rather than the fresh food baits. Through concerted efforts over a considerable period of time, the physiologically relevant volatiles from the food baits were identified by combing with chemical and biological detectors, followed by wind tunnel behavioural assay. Thus, a 'kairomone blend' (having major and minor components) along with the pheromone (4 methyl 5 nonanol + 4 methyl 5 nonanone 9:1) was found to induce maximum activation. The next step was stringent evaluation of its field efficacy. Field evaluation at several locations across the major coconut tracts in India showed excellent results, with the pheromone loaded in nanomatrix combined with a kairomone blend' trapping higher number of weevils than the reference commercial lure (alone), thus ensuring better efficiency and better cost-effectiveness besides making it very user-friendly in the field.

Value addition: The need of the hour

Traditionally, the share of value added products from coconut (apart from coir and coir based products) in the Indian export basket is very negligible. The silver lining is that the situation has started changing over the last few years. It is really heartening that the export of coconut products (except coir and coir products) during 2014-2015 rose by 13.5 per cent to Rs.1,312.38 crore, against Rs.1,156.12 crore during 2013-2014. The most notable thing is that the export earnings from coconut shell-activated carbon alone was Rs.588 crore and virgin coconut oil recorded a significant increase (in both quantity and value) to reach Rs.24.72 crore, up from Rs.4.81 crore during 2013-14. This encouraging trend continued in 2015-16 also, fetching a record Rs. 1,450 crore, an increase of 10.50 per cent over the previous financial year. This achievement is all the more creditable in the backdrop of the overall picture of merchandise export from India showing a negative growth. However, a disturbing reading amidst this happy tidings is the reports that "in spite of the high demand for organic virgin coconut oil, the order for exports could not be met due to limited production of certified organic virgin coconut oil", a food for thought for all the concerned.

Evidently, there is no room for complacency, as there are plenty of opportunities still to be exploited. An exemplary case is that of Sri Lanka, which is a major exporter of value added products, though not a major producer of coconut. It may seem unbelievable that coir pith (a refuse from coconut fibre industry) from Sri Lanka is in great demand in USA, Europe and Australia, as an important ingredient of soilless potting media. Juxtaposed with this is the all too familiar sight in the west coast of India, especially in the coastal Kerala, where one can see heaps of coir pith, often rising to the heights of small hillocks, dumped in the premises of fibre extracting units.

Neera (Kalparasa), the nutritious health drink from coconut inflorescence, is actually the phloem sap rich in sugars, protein, minerals, anti-oxidants and vitamins and is literally the 'health and wellness capsule' in every drop. Moreover, the glycemic index (rate at which sugar is absorbed in blood) is found to be low in neera. The fresh sap has a very good colour like honey and it is sweet and delicious. Neera is virtually the game changer for the coconut farmers faced with low profitability, consequent on high cost of cultivation and lower prices for the traditional products (copra/oil) coupled with the market uncertainties. Even by conservative estimates, it has been demonstrated that a farmer tapping 15 coconut palms for neera could earn on an average net profit of Rs 45,000 a month, while a tapper can earn about Rs 20,000 per month.

Realizing its huge potential, the Institute has developed a simple ice box technology (Cocosap chiller) to collect farm-fresh, hygienic, unfermented sap from coconut palm, totally free from contamination with insect, ants, pollen and dust particles. The sap, thus, collected under cold condition remains fresh and unfermented, and can be stored for any length of time under refrigerated conditions. The sap, thus, obtained can straight away be consumed as ready-to-serve drink or can be used for the preparation of natural sugar, jaggery, honey or other value added products without the addition of any chemicals, for which technologies are also developed. Besides, a bottling technology has been developed for neera to extend its shelf-life up to 45 days under refrigerated condition without adding any preservatives and additives. Coconut sugar based products such as Kalpabar , a dark chocolates and Kalpa drinking chocolates in collaboration with CAMPCO and various other value added products include, extruded product (Kalpakrunch), ice creams, chips and neera based sweets were developed.

Empowering the Value Chain in Coconut

To strengthen the value chain involving production, community level processing of coconut, and marketing, a consortium of three research institutions viz., Central Plantation Crops Research Institute, Kasaragod, Kerala Forest Research Institute (KFRI), Peechi, and Defence Food Research Laboratory (DFRL), Mysore was formed under the proposed project.

Effective linkages were established with agencies such as Coconut Development Board, State Department of Agriculture, and women SHGs to implement the project. In the upstream end of the value chain Community Based Organizations (CBOs) were formed in selected Panchayats to overcome the structural rigidities of coconut homesteads for adopting production technologies. The CBOs formed were further strengthened with sustained provision of technological and knowledge inputs. Participatory assessment of coconut farming scenario in all the selected clusters was carried out. Prior to implementing, project sensitization meetings were conducted in the clusters to create awareness on the project objectives, activities, plan and mode of operation. Various interventions related to productivity enhancement as well as product diversification proposed under the project were discussed in detail. Based on the area under coconut, dependence of coconut farming as the main source of income, willingness for implementing the proposed intervention, proximity etc. farmers were selected. Clusters were formed by conducting a reconnaissance survey by the experts along with the Grama Panchayat. Community Based Organizations (CBOs) of coconut farmers were formed in the identified clusters for easy implementation of the interventions.

The baseline survey, prior to implementation, indicated that agriculture was the prime occupation of the farmers in two-third of the holdings selected. More than 65% farmers were having 20 or more years of experience in farming and the holdings selected were predominantly garden lands and coconut was the prime cultivated crop.

Value added products like sugar, virgin coconut oil, chips, extruded products, chocolates

However the level of adoption of improved production and processing technologies including plant protection was found to be very low indicating the need for suitable interventions.

Coconut basin management with leguminous creepers, inter/mixed cropping in coconut gardens, integrated nutrient management, integrated pest and disease management, soil and water conservation measures and organic recycling through vermicomposting were the interventions introduced to enhance productivity and profitability and higher resource use efficiency. The average yield of coconut in the selected gardens prior to the implementation of the project was 62 nuts/palm (in the year 2007-08). After three years of implementation of the project, the coconut yield was increased to 112 nuts/palm which was 80% more than the yield reported during the base line survey. The increase in yield was mainly due to the agro techniques implemented in the gardens.

In order to overcome the problems encountered by farmers in harvesting coconut, climbing devices were popularized. The available devices were evaluated for technical merits, user friendliness by taking in to account the perspectives of skilled labourers on the use of such devices and it was found that the 'Chemberi Model climbing device' was more efficient than other models and so four machines of this model were supplied to each cluster for timely harvesting of coconut.

An array of high value added products were developed through the project viz., Virgin Coconut Oil (VCO), Coconut Chips, Coconut Vinegar and VCO meal based confectioneries . An activated carbon plant was designed for the production of pollution free coconut shell charcoal for community level processing at small scale level. This is indeed a breakthrough output of the project. With regard to the commercialization of technologies the project could successfully develop market for the value added products through well established link with the retail distributor. Moreover, the marketing functionary was made a part of the value chain through appropriate integration techniques adopted and there by ensured the efficient functioning of the chain.

Women Self Help Groups (SHG's) were formed to produce value added coconut products. Technical know-how including hands on training was given to them on production of coconut chips and virgin coconut oil (VCO) from coconut kernel, vinegar from coconut water, and VCO meal based confectionaries. Incubation support was given whenever required, especially at the beginning to start such coconut based enterprises. Apart from technical aspects, good practices of food processing, attractive packaging with information desired by the consumers, quality control, procurement plan of raw material, pricing, and marketing were also taught to these SHGs. The processing units procured the required raw material (coconuts) produced by the CBOs to prepare value added products and marketed either directly or through other marketing agencies. The net result of these interventions was observed as gaining more income to the farmers, employment generation to women folk and creation of entrepreneurship among the farmers. On seeing the success of these farmers, many neighboring groups of farmers have taken up these technologies for implementing in their field.

Harnessing the synergy from linkages and collaborations

Right from the beginning, there were conscious efforts at fostering linkages and enlisting partnerships in collaborative research programmes, both at national and international levels. At the national level, work on electron microscopy for the investigation on etiology and remote sensing technique using infra-red aerial photography for diagnosing root (wilt) disease in early stage were in progress in collaboration with IARI and ISRO. A project on agrostology and mixed farming was initiated in collaboration with the Indo-Swiss Project at Mattupatty and the Intensive Cattle Development Project, Kerala.

As early as 1970, international level investigations on bud rot of coconut were in progress with USAID under the PL-480 programme. Collaboration with

Community adoption of technologies through farmers participatory approach, biological control of leaf eating caterpillar near Udupi, Karanataka,

the Common wealth Institute of Biological Control (presently ICAR-NBAIIR), Bangalore was facilitated for work on biological control of mites. Another area in which the institute was making concerted efforts to obtain collaborative support for the ongoing research programme was the root (wilt) disease. There were four consultancy visits from overseas,by Dr FO Holmes (Rockefeller Institute, New York) in1964, Dr B Weischer (University of Munster, West Germany) in 1966 - 1967, Dr JW Randles (University of Adelaide, South Australia) and Dr DJ Raski (University of California, Davis) in 1979 to study the problem.As part of the Indo-UK protocol signed in 1977-78 under the Natural Resources Development Programme, the CPCRI was identified to partner with Rothamsted Experimental Station, the biggest and the most prestigious agricultural research station in UK, for taking up co-operative research programmes on root (wilt) disease of coconut and yellow leaf disease of arecanut

International collaborations with BIOVERSITY/ COGENT/APCC in coconut research and development was further strengthened in the 1990's with several IFAD/DFID/COGENT funded projects taking off.A total of 20 projects were undertaken by the Central Plantation

Crops Research Institute (CPCRI). Funding support for coconut PGR-related projects amounted to a total of US$ 392,600 out of which US$ 215,975 was provided by ADB, APCC, DFID and IFAD, while US$ 176,625 came from counterpart financing by ICAR. Under this initiative, several meetings/conferences/workshops were held in India from 1995 to 2005, with CPCRI hosting the 4th COGENT Steering Committee Meeting and CGRNAP Annual Review and Planning Meeting in 1995 at Kasaragod and the 14th COGENT Steering Committee Meeting in 2005 at Mangalore.

The International Coconut Gene Bank for South Asia (ICG-SA), one among the five multi-site genebanks established by FAO/Bioversity-COGENT to promote conservation as well as exchange of coconut germplasm for the benefit of the coconut community, was established under a tripartite agreement among ICAR-FAO-ITPGRFA. Planting of coconut accessions in the ICG-SA, located at CPCRI Research Centre, Kidu, Karnataka, was initiated in 1998. In the initial years, Indian coconut germplasm was regenerated and planted in the Gene Bank. Subsequently, the genetic base of the ICG-SA was broadened with the introduction of exotic coconut germplasm. A total of 91 accessions have been planted over the years in the ICG-SA, representing coconut germplasm from the host country (India) as well as coconut ecotypes collected through COGENT-ADB from Sri Lanka, Bangladesh, Indian Ocean Islands of Mauritius, Madagascar, Seychelles, Comoros, Reunion and the Maldives.This genebank is the treasure house of genetic diversity to combat the immediate challenges of the present and the emerging exigencies of changing climate.

Participatory and co-learning approaches in extension

With the passage of time, the dreary 'preaching, teaching and monologues' have given way to more meaningful 'dialogue and engagement' with the stakeholders. This shift from the conventional 'transfer of technology' model to participatory co-learning and decision-making support could improve the extension service delivery and serve as an important strategy for the extension machinery to engage a broader client constituency. Two landmark advances in this approach were the evolving of a technology delivery mechanism for area wide community adoption of technologies (like IPM of rhinoceros beetle and red palm weevil in coconut) and developing methodologies for assessing and enhancing of group performance and group capacity of community based organizations in coconut sector. Assessment and refinement of technologies are done with the active participation of farmers, by organizing various programmes with the cooperation of developmental departments/ commodity boards. Thus, research and extension activities have been fine tuned considering the demand of the stakeholders.

Steering the coconut development: The Coconut Development Board

Developmental activities for coconut in India are mainly taken up through the department of agriculture and the Coconut Development Board. The main objectives of the schemes taken up by the department are to facilitate the adoption of economically viable farming system and to maximize productivity of coconuts through cut and removal of old and senile palms, replanting with disease tolerant seedlings, scientific management of the existing coconut gardens and providing irrigation facilities. Apart from this, augmenting production of planting materials through departmental farms, coconut crop insurance and other schemes through Rashtriya Krishi Vikas Yojana are being implemented by the department. The Central schemes implemented by the department are the production of T x D hybrid seedlings and establishment of regional nurseries as well as national project on organic farming and CDBs scheme for integrated farming in coconut holdings for productivity improvement.

Coconut Development Board under the Ministry of Agriculture was established in 1981 with its headquarters in Kochi for the development of coconut cultivation and allied industries. The Board commenced implementing developmental programmes from 1982-83 which was the third year of the Sixth Five Year Plan Period. Programmes triggering the production, processing and

Area wide bio-management of rhinoceros beetle through farmer participatory approach at Bharnikavupanchyat, Kerala

Friends of Coconut Tree, woman empowerment

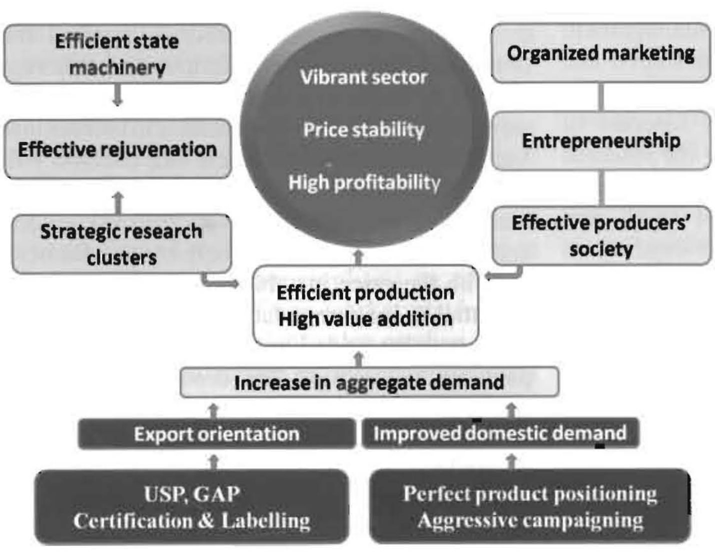
export were effectively implemented through schemes viz; production and distribution of planting material with emphasis on dwarf and hybrids, expansion of area under cultivation, integrated farming for productivity improvement, technology demonstration, coconut palm insurance scheme, and replanting and rejuvenation of coconut gardens. Realizing the importance of production and distribution of planting material, the Board has implemented various programmes, including production and distribution of hybrids and other improved varieties through state departments, establishment of regional coconut nurseries and assistance for establishment of nucleus seed gardens/ nurseries. Considering the importance of identifying suitable varieties and enhancing the production of seedlings, demonstration-cum-seed production farms were established in different agro climatic region of the country.

The Govt. of India sanctioned the Central Sector Scheme "Technology Mission on Coconut" (TMOC) during January 2002 to provide technical support, evaluation and emergent requirement, management of insect pest and diseases as well as processing for value addition and product diversification. The new initiatives of the Board include enhancing the productivity and income from unit area of coconut holdings through cluster approach, rejuvenation and replanting in coconut gardens, creation of skilled labour bank through "Friends of Coconut Tree" programme etc. Welfare schemes like coconut palm insurance scheme and "KeraSuraksha" insurance scheme for coconut tree climbers are also implemented by CDB.

Recently the Board has initiated formation of Coconut Producer Societies (CPS) by mobilization of small and marginal coconut farmers in a contiguous area and their federated forms of Coconut Producers Federation (CPF) and Coconut Producers Company aimed at socio economic upliftment of the farmers through productivity improvement, cost reduction, efficient collective marketing and processing and product diversification. At present, 65 Coconut Producer Companies have been formed around the country.

The road map for a vibrant coconut sector

The immediate priorities for improving the coconut production is the massive removal of senile and disease affected coconut palms which are beyond recovery, regulating the palm density, and replanting with high yielding planting materials along with adoption of suitable agro-management practices in farmer participatory cluster mode. It is of paramount importance to develop an exclusive policy for production and supply of elite planting materials to the farmer. Further, to increase the quality seedling production in coconut, it is necessary to develop coconut seed gardens in a Private Public Partnership (PPP) mode so that the enhanced seedling production to the tune of 50% of the expected demand can be assigned to Coconut Producers Societies, accredited Coconut Nurseries and NGO's, through a decentralized seedling production programme which would thereby effectively complement the quality



Restructured innovation system of coconut sector for a vibrant coconut economy planting material production from the government sector. Moreover, since most of the existing seed gardens have been established more than 25 years back, the existing mother palms (especially dwarfs) in such seed gardens are nearing senility. Hence, urgent action should be initiated for replanting such seed gardens with parental lines of new and improved varieties recommended for the respective regions. Further, to increase the capacity for hybrid seedling production, a decentralized production mechanism is to be envisaged by maintaining a centralized pollen storage and supply mechanism.

It is also essential to develop a system of mandatory accreditation of all coconut nurseries. Meanwhile, sale of coconut planting materials from other non-recognized agencies should necessarily be banned to prevent sale of spurious planting materials. This is of greater significance in plantation crops like coconut, since there is a long juvenile phase and the genetic potential of the palm will be visualized only after a few years of planting, and use of inferior palms for planting would result in huge loss to the growers in terms of production capability and input-use efficiency.

Rainfed cultivation of coconut is one of the major reasons for low productivity. The water scarcity being experienced by the palms during December to May months causes reduction of yield during the lean periods. Irrigating coconut palms wherever possible could be adopted. The drip irrigation system along with fertigation is found to be the best suited with maximum water saving and fertilizer use efficiency. There is need to provide assistance to the coconut sector for large scale adoption of this technology.

Massive campaigns for on farm organic matter recycling, identification and effective management of pests and diseases (especially red palm weevil and bud rot) in decentralized (panchayat level) mode are necessary. Crop surveillance and timely forecast of disease incidence should be carried out by the research and development agencies in endemic areas. Capacity building programmes for the benefit of small and marginal farmers on identification/understanding of field problems and adopting solutions is also essential. Besides, strengthening and popularization of systematic coconut based farming system as a strategy to make coconut farming economically viable in small holdings need to be highlighted. Financial assistance extended under NHM as well as other state schemes can be made available to the farmers for adopting coconut based farming system.

It has been indubitably proved that a large number of value added products could be made from coconut meat, water, shell, coir pith through composting etc. Therefore, promotion of farm level and community level processing of diversified products and byproducts obtained from coconut palm are highly imperative. Tender coconut marketing is one of the profitable activities which need to be promoted in the state. Farmer's collectives as well as enterprising youths are to be supported in organizing marketing outlets in potential areas for tender coconut. This not only helps to improve the farm level economy of farmers, but also create opportunities for employment to the rural youth in the country.

Kalaparasa outlets

Another strategic area yet to be utilized in the state is production of neera and palm sugar. Technologies are now available for preserving and packing coconut sap as 'neera 'or sweet toddy as non-alcoholic health drink. The Government of Kerala has issued license to various Farmer Producer Organizations on a pilot scale in all the districts of Kerala to produce, process and market neera and Karnataka is a follower in this regard. The CPCRI technology for the collection of inflorescence sap (Kalparasa) is very hygienic and contamination free. Various value added products like coconut palm sugar, palm jaggery, coconut honey and coconut syrup can be made from neera. If effectively utilized, tender coconut and neera, are capable of helping the farmers to cope up with the price instability in coconut. Therefore it is essential to encourage farmers' organizations to produce various value added products from neera in attractive packing and exploit the domestic and international markets.

Encouraging more entrepreneurs in coconut sector by establishing 'Coconut Parks' by state governments for organized processing for value addition will help coconut farmers to de-link the over dependence on coconut oil in determining coconut price. To begin with, Coconut Parks may be set up in districts with an area more than 20,000 ha under coconut cultivation.

Unilateral increase in production alone will not help the sustenance and stability of the sector. The growth of production must be supplemented with guaranteed procurement and remunerative price for the farmers. In order to create an impact in the market and for the benefits of MSP to reach the genuine coconut farmers, adequate quantity of copra should be procured. The studies on pattern of distribution of annual yield of coconut indicates that the number of nuts harvested, varied from harvest to harvest, and 60% of the production of a coconut palm is harvested during the peak production period i.e., the first six months of the calendar year, and hence a stable price during these periods is utmost important. The copra procurement scheme should be designed keeping view of this important aspect of coconut production. Along with this, making available skilled climbers for undertaking timely plant protection operations as well as harvesting is another serious concern. Therefore, stakeholders must contemplate on this issue to come up with a sustaining labour bank for coconut climbing and related operations.

Participatory research involving farmer groups for refining and fine tuning of technologies for higher efficiency of the sector is to be given greater emphasis. Farmer organizations are to be facilitated for meaningful partnership in technology generation and transfer for achieving efficiency in coconut commodity chain. Integrating youth/women farmers organizations with other main stream groups in agriculture with leadership roles and mainstreaming functions should be supported with policy prioritizing, for empowerment of the target groups and sustained development of the coconut sector.

Summing Up

The current sectoral innovation system of coconuts in the country has huge strengths on the research front of coconut, but the lack of price stability, inadequate price support mechanism and marketing facilitation are the factors detrimental to the functioning of coconut value chain in the state. The lack of effective group coherence among different stakeholders is still remaining as a problematic facet. The Institutes should take a lead role to re-engineer and revitalize the coconut sector in the state by providing adequate emphasis on product diversification and creation of neo-market platform to promote coconut as a high nutrient value product.

With the growing realization of lesser profitability in small farm holdings, producers/farmers should be encouraged to get together and form into small cooperatives or crop based organizations to develop and utilize community facilities for farm operations, post harvest processing and marketing to economize on production as well as marketing costs. For the vision of developing a sturdy and vibrant coconut industry which does not depend on copra/oil to come true, we need to come up with breakthrough coconut products which

Agribusiness planning centre at CPCRI for value addition in coconut.

are strong enough to capture the niche export market segment. As the technologies are adopted only when profitable, policy interventions in market and regulation of trade tariffs to the benefit of the industry to compete with global players are the way forward. To encourage investments in the coconut sector, the government, as matter of policy, must consider coconut as a priority crop in its national agricultural development agenda. The government and private financial sector through the banking system should provide support through reasonable credit schemes for coconut processing business ventures.

At present, the ambience of coconut sector in the domestic arena is positive wherein the horizontal node of the value chain aspect is strengthened by the formation of Coconut Producer's Society at the grass root level to Producer's Company at the highest level. Thereby provides an excellent auxiliary support for the ambitious export orientation programmes. The strategic positioning of developmental and research support (CDB, CPCRI, KAU, NAFED) is another very important factor which will provide the much needed impetus for the sectoral development. Moreover, Indian export sector has become vibrant with very high growth rate since CDB has upgraded to the status of Export Promotion Council (EPC).We may also develop an organic coconut supply chain targeting the niche high priced outward markets in the world. It is certain that in the near future, together we may create a vibrant, equitable and sustainable coconut sector through innovative and inclusive programmes and policies that contribute towards prosperity of all stakeholders of coconut. ■