

Empowering coconut growers with viable technologies

Coconut palm is of considerable global significance as a versatile tree crop, providing livelihood security to several millions of people. Being grown globally in 12.29 million ha in 93 countries and producing 11.04 million tonnes of copra (on equivalent basis), coconut influences the economy of several countries. India, Indonesia and Philippines are major producers of coconut in the world. Importance of this crop in providing livelihood security, improved nutrition, employment and income generation are driving forces for the renewed interest in its crop. Thus, coconut has high potential in food, shelter, industrial, pharmaceutical and energy uses in an environment-friendly way, says Dr H.P. Singh, DDG (Hort.), ICAR, New Delhi.

COCONUT by itself is a food crop, amenable for the preparation of a variety of food products. Coconut oil with high lauric acid content is considered as one of the best oils and coconut meat as an ideal source of dietary fibre and diverse food products that could be prepared from coconut. Considering the pivotal role of coconut, predominantly a small holder's crop, and coconut-based farming system in ensuring livelihood security of millions of farmers, it is imperative that the yield potential of all the crops of the system is holistically exploited so as to maximize the per unit area production.

RESEARCH SUPPORT FOR COCONUT IN INDIA

The need for coconut research was recognized as early as in 1916 by establishing four research stations by the then Government of Madras, at Kasaragod (red loamy soil) and Pilicode (laterite gravelly soil), and two centres at Nileswar (red sandy loam soil and coarse sandy soil) in northern Kerala. The Indian Central Coconut Committee was set up in 1945, under the "Indian Coconut Committee Act, 1944" to take measures for the improvement and development of coconut to serve the entire need of the country. In 1966, Indian Central Coconut Committee was abolished and the development of the crop was entrusted to the Directorate of Coconut Development, under the Ministry of Agriculture, Government of India, and the research was entrusted to the Indian Council of Agricultural Research. In 1970, ICAR established Central Plantation Crops Research Institute (CPCRI) by merging the stations at Kasaragod and Kayamkulam and the Central Arecanut Research Station at Vittal with the five Regional Stations.

The CPCRI is the national institute to conduct research on coconut and has Regional Stations at Kayamkulam, Vittal and Minicoy and Research Centres at Kidu, Mohitnagar and Kahikuchi. The Institute addresses the problems related to crop improvement, production technology including management of pests and diseases and also some aspects of post-harvest handling. During 1970, ICAR also sanctioned the All India Coordinated Coconut and Arecanut Improvement Project with its headquarters at Kasaragod. At present, the AICRP is implemented in 16 Centres located in nine State Agricultural Universities and one Central Institute. The research efforts have recorded impressive achievements in terms of developing new cultivars and production technologies, which when demonstrated in the field resulted in two-three fold increase in yield.

Coconut Chandrakalpa



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BIODIVERSITY CONSERVATION AND UTILIZATION

Collection, conservation and cataloguing of coconut germplasm have been accorded the topmost priority in coconut research. The first exotic collections were made way back in 1924 from Philippines, Malaysia, Fiji, Indonesia, Sri Lanka and Vietnam. During 1940, the first germplasm bank was conducted at the erstwhile Central Coconut Research Station, Kasaragod. The first indigenous survey for germplasm collection was started in 1958. Later on, in 1981, under the FAO/IBPGR funded expedition, 24 exotic collections were made from six Pacific Ocean Islands, viz. Papua New Guinea, Fiji, American Samoa, Tongo and French Polynesia. At present, the Institute maintains the largest coconut germplasm collection in the world which comprises 398 accessions, of which 132 are exotic collections from 26 countries and 266 are indigenous collections. One of the important additions made recently to the germplasm is a rare accession "Thairu Thenga" (similar to makapuno type) from Andaman Islands.

Breeding efforts at CPCRI and State Agricultural Universities have resulted in release of several varieties (Table 1) and hybrids (Table 2) suitable for different parts of the country.

Table 1. Coconut varieties released by CPCRI and SAUs for commercial cultivation

Variety	Remarks	Area recommended
Chandrakalpa	Drought tolerant, high oil content- 72%	Lakshadweep, Kerala, Tamil Nadu
Kerachandra	High yield	All regions
Kalpa Pratibha	High nut, oil yield, tender nut, drought tolerant	Kerala, Tamil Nadu
Kalpa Mitra	High nut, oil yield, drought tolerant	Kerala, West Bengal, Andhra Pradesh
Kalpa Dhenu	High nut, oil yield, drought tolerant	Andaman, Kerala, Tamil Nadu
Chowghat Orange Dwarf	Dwarf, Tender nut	All regions
Gautamiganga	Dwarf, high yield, tender nut	Andhra Pradesh, Tamil Nadu
Kalparaksha	High nut, oil yield in RWD prevalent areas	Kerala
Kalpasree	Dwarf, superior oil, high yield in RWD prevalent areas	Kerala
Pratap VPM-3	High yield, drought tolerant	Konkan region, Kerala, Tamil Nadu
ALR 1	High yield	Tamil Nadu
Kamrupa	High yield	NE region- Assam
Kera Sagara	High yield	Kerala
Kera Bastar	High yield	Chattisgarh
Kera Keralam	High yield	Tamil Nadu, Kerala
Kalyani Coconut	High yield	West Bengal
Kalpatharu	Drought tolerant, ball copra, high yield	Kerala, Karnataka, Tamil Nadu

Empowering coconut...

Table 2. Coconut hybrids released by CPCRI and SAUs for commercial cultivation

Hybrid	Parentage	Copra yield (kg)	Area recommended
Chandra Sankara	COD × WCT	25	Kerala, Karnataka, Tamil Nadu
Kera Sankara	WCT × COD	21	Kerala, Karnataka
Chandra Laksha	LCT × COD	21	Kerala, Karnataka
Laksha Ganga	LCT × GBGD	21	Kerala
Kera Ganga	WCT × GBGD	21	Kerala
Kera Sree	WCT × MYD	24	Kerala
Kera Sowbhagya	WCT × SSAT	25	Kerala
Ananda Ganga	ADOT × GBGD	21	Kerala
Godavari Ganga	ECT × GBGD	21	Andhra Pradesh
VHC-1	ECT × GD	13	Tamil Nadu
VHC-2	ECT × MYD	16	Tamil Nadu
VHC-3	ECT × OD	25	Tamil Nadu
Konkan Bhatye CH-1	GBGD × ECT	22	Konkan
Kalpa Sankara	CGD × WCT	18	Kerala
Kalpa Samrudhi	MYD × WCT	25	Kerala, Assam

Biotechnological Advancements

Efforts made to harness biotechnological tools have yielded fruitful results in addressing the problems in coconut. A protocol for aseptic collection of embryos in coconut, their storage and successful culturing to develop plantlets has been standardized. Many exotic coconut accessions were collected using this technique from Indian Ocean Islands. Besides, plantlet development has been obtained from various explants of coconut (plumular and inflorescence tissue) in Y3 medium supplemented with polyamine and picloram in both dwarf and tall cultivars. The technique of plumular culture is being utilized for scaling up the planting material production in coconut and development of more uniform coconut populations.

Significant achievement has been made in establishing etiology of root (wilt) disease, which is the most serious production constraint for coconut in India, by application of molecular techniques. The PCR assay of DNA extracted from root (wilt) diseased palms with phytoplasma specific primers amplified expected bands and phytoplasmic nature of amplicons confirmed by sequencing. Phylogenetic analysis of root (wilt) phytoplasma by BLAST search revealed that the phytoplasma belong to 16Sr DNA XI group.

TECHNOLOGIES FOR PRODUCTION SYSTEM MANAGEMENT

Agronomic trials conducted during early forties and fifties helped to determine the optimum manurial and cultural requirements of coconut palm. The first systematic trial on cropping system was laid out in 1972 at CPCRI. Nursery management techniques such as selection of garden, mother palms and seed nuts, planting and

maintaining the nursery and the technique for raising poly bag nursery were standardised. Square system of planting at a spacing of 7.5 m × 7.5 m with a plant density of 175 palms/ha is recommended. Recommended dose of fertilizer for coconut palm is application of NPK @500:320:1200 g/palm/year in two split doses during May-June and August-September. Application of magnesium sulphate @ 500 g MgO/palm was found to be advantageous in areas where palms show yellowing of leaves.

Water Management

Sprinkler irrigation or perfo-irrigation with 20 mm water is best suited to inter or mixed cropping systems where the entire surface requires wetting. Drip irrigation system was found to be more advantageous under littoral sandy soil than lateritic soil and irrigating palms with 66% Eo (32 l water/palm/day) from December to May is ideally suited for coconut resulting in 34 per cent saving of water. Fertigation studies in coconut have indicated that 50% NPK of the recommended dose of fertilizer through drip irrigation network has given the highest yield. A non-sequential irrigation system with an electronic tensiometer system or alternatively with gypsum sensor was designed at CPCRI.

Soil and Moisture Conservation

Moisture conservation methods such as mulching with coconut husk, coir dust, green leaves, dried coconut leaves, addition of organic manures or green manures, husk burial, inter cultivation, bunding, terracing etc. are ideal. In sloppy terrains, trench filled with coconut husk, half moon bunds, staggered catch pit reinforced with pineapple and growing CO3 grass across the slope were found to be useful. The Institute has developed various bio-engineering measures to sustain crop production in rainfed areas of west coast region.

Coconut-Based Cropping System

Various coconut-based cropping system models involving different compatible crops like vegetables, tuber crops, flowering, medicinal and aromatic plants, fruits, spices etc. in the interspaces of coconut palms have been developed. Application of two-thirds recommended dose of fertilizers for coconut along with organic matter

recycling was found to be the most ideal nutrient management system under the High-Density Multi-Species Cropping System. Mixed farming with various subsidiary enterprises including animal husbandry component was found to be quite advantageous.

Coconut Gardens in Coastal Sandy Soils

Coastal sandy soils are inherently poor in organic matter and soil nutrients as well as are poor in water-holding capacity. The CPCRI has developed technologies for overcoming these problems and could successfully cultivate coconut and other intercrops. Various intercrops such as banana (G9 variety), pineapple, ash gourd, okra, brinjal, Amaranth, elephant foot yam, Hybrid Bajra and Napier grass (CO 3) were grown with various soil moisture conservation measures. Burial of coconut husk in trenches or application of coir pith in trenches and planting intercrops was found to give better plant growth and higher yield. Among different cropping systems tried, coconut + vegetable intercropping system recorded higher coconut productivity. The coconut-based mixed farming system involving cultivation of fodder grass in the interspaces of coconut gardens and integration of animal enterprises involving dairy, poultry and pisciculture is in progress at CPCRI, Kasaragod.



Coconut growing in coastal sandy land

Organic Farming

Technological advancements made in organic farming research resulted in the development of viable protocol for sustainable coconut production, employing organic and bioinputs. Vermicomposting of coconut leaves using local strains of *Eudrilus* sp., production of vermivash from coconut leaf vermicomposting system, utilization of legume- *Rhizobium* N₂ fixing systems, biofertilizers and eco-friendly pest and disease management techniques were found to be valuable inputs for organic farming in coconut.

Precision Farming

In general, highly-weathered soils in the high rainfall zones commonly suffer from multiple nutrient deficiencies. The regression analysis of the soil available nutrients at different levels to coconut yield indicated existence of multiple nutrient limitations. Analysis for Multiple Nutrient Limitation Hypothesis of soil available nutrients and individual palm yield data in red sandy loam soil at

CPCRI, Kasaragod, has indicated that increasing level of available K at high level of total N had a linear increasing effect on coconut yield, suggesting that N and K have a co-limiting role.

Diseases and Pest Management

Various diseases and pests affect growth and inflict considerable loss in coconut production. The CPCRI and various centres under AICRP on palms are working on their management and various technologies have been developed for tackling these problems.

Integrated Disease Management

The coconut root (wilt) disease is a non-lethal debilitating malady, caused by Phytoplasma that reduces the production potential of the palm. ELISA technique has been refined for the quick and easy detection of root (wilt) disease of coconut. Scanning electron microscopic (SEM) observation of root tissues of root (wilt) diseased palms and PCR with root (wilt) phytoplasma primers revealed presence of phytoplasma in the samples.

Bud rot caused by *Phytophthora palmivora* is another important disease of coconut and unless the management has not been adopted well in advance, under severe cases, can completely kill the palm. Pouring of 5 g Mancozeb in 300 ml water coupled with placing of 2 nos. of Mancozeb sachets (5 g Mancozeb/sachet) in the innermost leaf axils around spindle leaf was found to be very effective in controlling disease.

Leaf rot disease in coconut is caused by a complex of fungal pathogens (*Colletotrichum gloeosporioides*, *Exerohilium rostratum* and *Fusarium solani*). Integrated disease management strategy involves cutting of the rotten portions of the spindle leaf and pouring either Contaf-5EC@ 2 ml or Dithane-M45/Indofil-M45 @3 g dissolved in 300 ml water in the cavity around the base of spindle leaf. Field management of leaf rot disease through application of biological control agents especially consortium of bio-agents (*P. fluorescens* and *B. subtilis*) along with phytosanitation was proved to be effective.

The stem bleeding disease caused by *Thielaviopsis paradoxa* can also affect growth and yield of palms, if left

unmanaged. Root feeding of 5% Calixin or 5% Bavistn at quarterly intervals is effective in the initial stage of the disease. In advanced stage, the affected bark should be chipped off till the healthy tissue is exposed and painted with 5% Calixin (5 ml Calixin in 95 ml water).

Integrated Pest Management

Rhinoceros beetle (*Oryctes rhinoceros*) is a major pest of coconut prevalent in all coconut growing areas. The IPM package for control of rhinoceros beetle includes extraction of the adult beetles using a beetle hook during the peak period of pest abundance (June-September) from the crown, treatment of all possible breeding sites of the insect with Carbaryl 0.01% (50% WP) on w/w basis.

Biological suppression of the pest can be carried out by releasing 10-15 beetles inoculated with *Oryctes* virus in one ha of garden and application of 5×10^{11} spores of *Metarhizium anisopliae* fungus/m³ area of the breeding site of the pest, during monsoon period. Prophylactic measure includes leaf axil filling of palms with 12.0 g naphthalene balls or 250 g each of neem cake/marotti cake covered with sand at 45 days interval. The conventionally used PVC traps for catching adult beetles of rhinoceros beetle were refined for better efficiency.

Leaf eating caterpillar (*Opisina arenosella*) has sporadic occurrence and feeds on the under surface of the leaflets

Mixed farming with coconut





Coconut woman climbing to harvest coconuts

within silken galleries resulting in considerable reduction of photosynthetic area. The *Opisina* infested palms showed reduction in bunch and leaf production to the tune of 21.9 and 17.4%, resulting in a crop loss of 45.38% in terms of nut yield. An IPM method for controlling the pest includes cutting and burning of badly infested outer leaves/leaflets, spraying of 0.02% Dichlorvos if pest is

in active larval stage and release of larval parasitoids (*Goniozus nephantidis*) @ 20.5%, pre-pupal parasitoids like *Elasmus nephantidis* @ 49.4% and *Brachymeria nosatoi* @ 31.9% respectively at fortnightly intervals depending on the larvae, pre-pupal and pupal population of *Opisina*.

Eriophyid mite (*Aceria guerreronis*) is the most widespread pest affecting coconut palm in about 30 countries of tropical America, Africa and Asia. Management of this pest is possible by spraying of 0.004% azadirachtin or 2% neem oil, garlic and soap mixture during April-May, October-November and December-January, in such a way that all mite infested palms in an area should be covered at the shortest possible interval coupled with integrated nutrient management to improve the health of palms. Root feeding with neem formulations containing azadirachtin 50,000 ppm (5%) at 7.5 ml or azadirachtin 10,000 (1%) ppm at 10 ml mixed with equal volume of water is also recommended for managing the pest. Spraying of talc based preparation of virulent strains of the acaropathogenic fungus *H. thompsonii* (CPCRI -19; CPCRI. 51(2) @ three sprays at 45 days interval showed 56-88% reduction in eriophyid mite population.

Since coconut is a perennial crop and can act as a large carbon sequestration sink, it is essential to understand more about the cause-effects of climate change on coconut plantations with respect to the physiological efficiency of carbon sequestration, growth and yield. Development of more sustainable cropping system models by including compatible high-value low-volume crops that will optimize the utilization of natural resources and readily adopted by farmers are necessary. Development of effective formulations of agriculturally important microorganisms, viz. nitrogen fixers, phosphate solubilizers, PGPRs, mycorrhizae and organic matter decomposers and their applications to meet nutritional requirement and to achieve plant growth promotion are also needed.

POST-HARVEST TECHNOLOGY

Machineries

Coconut-dehusking machine: A manually-operated coconut-dehusking machine was developed with an output of 110 nuts/hour. A power-operated semi-automatic coconut dehusking machine was also developed, which can dehusk 500-600 nuts/hour.

Coconut dryers: Simple smoke-free collapsible copra dryers have been developed in which about 1,000 coconuts/batch can be dried in 24 hours. A solar-cum-electrical dryer with agricultural waste as third source of energy was also developed for coconut drying with a capacity of more than 3,000 nuts/batch.

Testa remover: A mechanical testa remover with a capacity to process 200 nuts per hour has been developed to achieve greater efficiency in removal of testa from kernel of mature coconut. As removal of kernel testa is the first step in production of value-added products such as coconut chips, and virgin coconut oil. It will greatly help accelerate the process of product development.

Coconut slicing machine: For faster slicing of coconut kernel and to ensure uniform quality, a manually-operated coconut slicing machine has been developed with a capacity to handle 50 coconuts per hour. The machine

consists of a pair of stainless steel slicing blades fixed on a circular blade supporting disc, a feeder, an exit guide and an electric motor as a prime mover.

Coconut palm climbing device: A serious problem faced by coconut farmers in undertaking timely harvesting and other plant-protection measures is the inherent difficulties involved in palm climbing and inadequate availability of skilled manpower. To address this problem, a simple coconut palm climbing device has

been developed by the Institute. The user can fix the climbing device to his feet by wearing the shoes attached to the device and can move up and down the coconut tree as easily as he climbs a vertical ladder.

Value-Addition

Snow ball tender nut: A technology for making snow ball tender nut (SBTN) from eight months old coconuts has been developed. Along with the process, a suitable machine has also been developed for making SBTN.

Coconut chips and vinegar: A technology for the production of sweet coconut chips has been developed,



Value-addition to coconut: coconut shell products (left) and coconut recipes (right)

by the process of osmotic dehydration, with a shelf-life of six months. A process for production of coconut chips with different flavours, medicated and spicy chips and instant coconut chips using microwave oven has also been developed. The technology for production of coconut vinegar from coconut water has been refined to produce better quality vinegar which will be more acceptable to the consumers.

Coconut tender nut: For easy transportation and to provide the tender nut a uniform and appealing appearance many small-scale entrepreneurs have started producing the minimally processed tender coconut. In order to make the dehusking process simpler and to avoid the risk involved in manual processing, a minimal processing machine has been fabricated to partially dehusk tender coconut. Using the two cutting blades especially fabricated for this purpose, tender coconut could be dehusked to any required shape.

Virgin coconut oil: The CPCRI has standardized the technologies for virgin coconut oil production by fermentation, hot and cold processes. Lipid profile of virgin coconut oil made through various processes like hot process, fermentation and direct micro expeller were analyzed. It was found that all these oils were containing high amount of C-12 Lauric acid (more than 50 %) and it is followed by C-14 Myristic acid (20 %) and other free fatty acids.

Value-added products: *Atta* incorporated with defatted coconut meal (3:1) is used for making *chapatti*. Sensory evaluation of *chapatti* shows high value in terms of colour, flavour, texture and overall acceptability. Nutritional evaluation of the fortified *atta* shows higher fat content than commercially available *atta*. Value-addition of tender-coconut wine using tender nut (kernel and water) and other ingredients has great potential. Coconut water squash is prepared from matured coconut water and their nutritional, sensory and consumer acceptability are found to be good. Nutritional evaluation of the product shows high sodium and potassium content in coconut water squash.

THRUST AREAS OF FUTURE RESEARCH

Molecular characterisation of genetic resources will provide the basic data for effective utilization of available genetic resources in breeding programmes. Identification of molecular markers associated with quantitative traits will accelerate the breeding programme. However, long breeding cycle and inherent zygoty hinder development of mapping populations for undertaking linkage mapping for identification of QTLs. The alternative approach to gene mapping (association or linkage disequilibrium mapping) using associations at the population level, therefore, offers an opportunity to identify associations between marker patterns and trait expressions.

Product diversification of coconut and development of value-added products become very much essential to derive maximum economic returns for the farmer and the industry. Developing economically and commercially viable processes for the production of virgin coconut oil and standardization of quality parameters will enable its large-scale production and higher export. A holistic approach for pest management integrating IPM and INM practices with the involvement of highly efficient bioagents, botanical pesticides, pheromones and biofertilizers is imperative to achieve higher productivity.

SUMMARY

Extension efforts are to be further strengthened so that the impact is trickled beyond the vast area/people interacted. Research-extension-farmer-market-development linkage is necessary to achieve faster dissemination of technologies. There is a need to utilize more efficiently the prowess of ICT tools including cyber extension programmes to develop linkages and faster sharing of information among the stakeholders in this vital sector.

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