COCONUT RESEARCH AT CPCRI - RECENT TRENDS AND ACHIEVEMENTS

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1. Introduction:

The Central Plantation Crops Research Institute (CPCRI) was established in 1970 under Indian Council of Agricultural Research (ICAR) by merging various research stations on plantation crops established since 1916 with the Research Station at Kasaragod as the head quarters. Though the institute had the mandate to cover a range of plantation crops viz., coconut, arecanut, cocoa, cashew, oil palm and spices, the research on cashew, spices and oil palm was delinked at different stages with the formation of separate institutes. CPCRI now conducts research on coconut, arecanut and cocoa. With the headquarters at Kasaragod (Kerala) the institute has three regional stations (Kayamkulam-Kerala, Vittal-Karnataka and Minicoy-Lakshadweep islands) and four research centres (Kidu-Karnataka, Mohitnagar-West Bengal, Kahikuchi-Assam, Kannara-Kerala). The research programmes are being undertaken under five divisions; Crop Improvement, Crop Production, Crop Protection, Physiology, Biochemistry and Post harvest technology and Social Sciences. The International Coconut Gene Bank for South Asia (ICG-SA) has been established at the research center, Kidu. CPCRI also serves as the headquarters of the All India Co-ordinated Research Project on Palms. Under this project research on palm species viz., coconut, palmyrah and oil palm is promoted and coordinated.

2. Research Progress and Achievements: Genetic resources

The institute maintains the largest coconut germplasm collection comprising of 360 accessions (228 indigenous and 132 exotic). The exotic collections are from 22 countries of South Asia, South-East Asia, Caribbean Islands, Indonesian Islands, Pacific Ocean Islands, African countries, Bangladesh and Sri Lanka (CPCRI, 2005).

Improved varieties and hybrids

The institute has released two high yielding varieties namely Laccadive Ordinary and Philippines Ordinary. Chowghat Orange Dwarf has been released as the best cultivar for use as tender nut. Three high yielding hybrids viz., Chandrasankara (COD x WCT) with an yield of 116 nuts/ palm/ year, Kerasankara (WCT x COD) with 108 nuts/palm/ year and Chandralaksha (LO x COD) with 109 nuts/palm/ year were released for large scale cultivation. These hybrids have the capacity to produce 1.62 to 2.99 tonnes of oil/ ha/ year.

The cultivar, Chowghat Green Dwarf (CGD), has been found to have field tolerance to the root (wilt) disease. The coconut hybrid, CGD x WCT (disease free high yielding palms in hot spots) was found to have relative tolerance to root (wilt) disease and high yield potential. WCT, Federated Malay States (FMS), Java Giant, Fiji, Andaman Giant, LO x GB and LO x COD have been identified as drought tolerant cultivars/ hybrids. Ninety five hybrid combinations are under evaluation.

Biotechnological advances

A protocol for aseptic collection of embryos in coconut, their storage and successful culturing to develop plantlets has been standardized. This is found to be very useful in field collection of coconut germplasm from distant places. A total of 405 embryo cultured coconut accessions collected from eight countries have been field planted (Anitha Karun, *et al.*, 1999). A protocol for extraction of tender tissues from adult coconut palm without destroying the growing apical meristem has been standardized.

Plantlet development has been obtained from various explants of coconut viz., plumular tissues, inflorescence in Y3 medium supplemented with polyamine and picloram in both dwarf and tall cultivars (Rajesh et al., 2005). In vitro active conservation of coconut zygotic embryos (short-term) was standardized (Anitha Karun, *et al.*, 1997). Cryopreservation of coconut zygotic embryos after desiccation pre- treatment was standardized and these embryos could be retrieved into plantlets. Protocol for DNA extraction from coconut leaf tissues was standardized.

RAPD/ISSR and SSR markers were used to establish the genetic similarity among some indigenous and exotic coconut accessions maintained at CPCRI, Kasaragod (Manimekalai, 2005). The protocol for AFLP, DAF and micro satellite analysis of coconut DNA for tagging resistance gene for root (wilt) studies was standardized.

WRKY proteins are plant-specific transcriptional factors associated with regulation of defense responses to both biotic and abiotic stresses. Degenerated PCR primers were designed to the highly conserved WRKY DNA binding domain and these were used to isolate putative WRKY genes from coconut. Six DNA fragments were isolated using five pairs of degenerate primers and these were cloned. Homology search of the deduced amino acid sequences against non-redundant Gene Bank protein database revealed significant sequence similarity of two of the cloned fragments to known WRKY genes. The other four cloned fragments showed homology to known stress responsive genes (Rajesh *et al.*, 2006).

Integrated production systems/technology

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 standardized. Square system of planting at a spacing of 7.5 x 7.5 m with a plant density of 175 palms/ ha is recommended. Application of 500g N, 320g P_2O_5 and 1200g K_2O/ palm/ year is recommended for coconut in two split doses during September and May. Application of magnesium @500g MgO per palm was found to be advantageous in areas where palms show yellowing of leaves.

Application of 200 l of water once in four days was recommended for irrigating coconut palms. For the WCT palms in red sandy loam soils on the west coast, perfo irrigation with 20 mm water, when cumulative pan evaporation was 20 mm, was found to be the best irrigation schedule. Sprinkler irrigation or perfo irrigation with 20 mm water was found to be the best suited to inter or mixed cropping systems where the entire surface requires wetting. Drip irrigation @ 66 % of the E_0 (32 litres of water per palm per day under Kasaragod conditions) from December to May is ideally suited for coconut resulting in 34 per cent saving of water (Dhanapal *et al* ., 1999). Application of straight fertilizers like urea, muriate of potash and phosphoric acid through drip system could reduce the fertilizer dose by 50 % and increased fertilizer use efficiency and yield of coconut. An automatic irrigation system suitable for all high frequency irrigation systems has been developed at an approximate cost of Rs. 2000/-, excluding the cost of irrigation system. Moisture conservation methods such as mulching with coconut husk, coir dust, green leaves, dried coconut leaves etc., addition of organic manures or green manures, husk burial, inter cultivation, bunding, terracing, etc. were recommended. The technique for utilization of leguminous cover crops such as *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium mucunoides, Cowpea* as green manures to supply biologically fixed nitrogen and easily decomposable biomass to coconut , to substitute for 50 % nitrogen fertilizer was standardized (Thomas and Shantaram, 1984). A field experiment conducted in a coconut plantation in an acidic laterite soil type revealed the feasibility of substituting upto 50% of fertilizer nitrogen with the nitrogen contributed by leguminous green manures (*Thomas, et al.*, 2001). *M.invisa* and *P.phaseoloides* are well nodulated by native rhizobia in acidic coconut soils. *Marasmiellus troyanus* and a local isolate of *Trichoderma* species were found effective for microbial composting of coir pith. Microbial enrichment of compost with N_2 -fixing bacteria and phosphate solubilisers was achieved.The technology for vermicomposting of coconut palm wastes by using a local earthworm, *Eudrilus* sp., closely related to the African night crawler, was standardized. Multiplication technique for the local *Eudrilus* sp. of earthworm using 1:1 cow dung-decayed leaves mixture was standardized and the earthworm is being distributed to the farmers to initiate vermicomposting (Prabhu *et al.*, 1998). Utilization of coconut wastes for oyster mushroom cultivation (*P. florida*, *P. sajor caju*, *P.flabellatus*, *P. opuntia* and P.*eous*) was found to be economically feasible. Coconut based cropping system involving cultivation of compatible crops like tubers, flowering, medicinal and aromatic crops, fruits, vegetables, spices, in the interspaces of coconut was economically superior to coconut monocropping. Coconut-based high-density multispecies cropping system (HDMSCS) involving many crops like tapioca, elephant foot yam, colocasia, banana, pineapple, nutmeg, clove, pepper, etc. was developed. Application of 2/3[rd] of recommended fertilizer dose for coconut is sufficient under the system to attain maximum yield and returns (Reddy *et al.*, 2002).

Growing Glyricidia as green manure crop was found to be ideal for management of littoral sandy soils and it had its beneficial effect on soil properties and yield of coconut. Application of Glyricidia prunings from interspace of one hectare of coconut garden can meet a major portion of nitrogen (90%), part of phosphorus (25%) and potassium (15%) requirement of coconut palm (Subramanian *et al.*, 2000).

Mixed farming in coconut by raising fodder crops in the interspaces with the integration of other enterprises such as dairy, poultry, and pisciculture was quite advantageous in increasing the productivity of the system, improving soil fertility and in enhancing the income from coconut plantations (Maheswarappa *et al.*, 2001).

For management of root (wilt) disease an integrated approach has been developed involving application of organic manures like farm yard manure or green leaf manure or composted coir pith or vermicompost at the rate of 25 kg/palm along with nitrogen, phosphorus and potassium application @ 500:300:1000 g through application of 1.1 kg of urea, 1.5 kg of mussorie rock phosphate and 1.7 kg of muriate of potash on per palm basis. Application of $MgSO_4$ @ 1kg per palm could reduce the yellowing symptom of the palms. Adoption of inter/mixed cropping with suitable crops and recycling of available biomass in the system could increase the productivity of the palms and reduce the yellowing symptom of the palms (Maheswarappa *et al.*, 2005).

Disease management

The root (wilt) disease, the most serious disease of coconut in Kerala, is a non-lethal debilitating malady, causing a gradual reduction in the production potential of the palm. The symptoms of the disease are characteristic bending of the leaflets termed "flaccidity", along with "foliar yellowing" and "marginal necrosis" (Radha and Lal, 1972). Phytoplasmal etiology of the disease has been reported based on Electron microscopic observations of the consistent presence of phytoplasma in the sieve elements of diseased palms and their absence in the healthy palms (Solomon *et al.*, 1998). Remission of the disease symptoms by tetracycline treatment and insect and dodder transmissibility of the disease further supported the phytoplasmal etiology (Mathen *et al.*, 1994).

Leaf rot disease, which is superimposed on root (wilt) diseased coconut palms is found to be caused by *Colletotrichum gloeosporioides and Exerohilum rostratum*. The symptoms are seen as presence of tiny spots of various shapes and shades and of different colours on the soft white leaflets of the unopened spindle, which enlarge and coalesce to cause extensive rotting (Srinivasan and Gunasekaran, 1992). Integrated leaf rot disease management strategy developed involves cutting of the rotten portions of the spindle and pouring either Contaf-5EC 2 ml or Dithane M-45/Indofil M-45, 3 g dissolved in 300 ml of water in the cavity around the base of the spindle leaf.

The etiological agent of bud rot disease is identified as *Phytophthora palmivora*. The symptoms of the disease include withering of the spindle, rotting of soft tissues of crown emitting foul odour and ultimately the death of the spindle. For management of the disease, root feeding and stem injection of Akomin (16.8 ml) and Calixin (21 ml) has been found to protect the palms for a period of 8 weeks. In early stages of the disease, application of 10% Bordeaux paste on affected portion can check the disease (CPCRI, 2005).

The stem bleeding disease is caused by *Thielaviopsis paradoxa* and is characterized by dark brown patches at the base of the trunk of the palm which grow into longitudinal irregular streaks with dark reddish brown liquid exuding from them. Root feeding of 5% Calixin or 5% Bavistin at quarterly intervals is effective in 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) (Ramanujam *et al.*, 1993).

The basal stem rot disease is also called as 'Ganoderma wilt'/ 'Anabe Roga'/ 'Thanjavur wilt'. *Ganoderma lucidum* and *G. aplanatum* are involved in the disease. In this disease, outer whorl of leaves turn brown and droop and bleeding symptoms appear on base of the stem. The recommended management practices include phytosanitation measures, digging trenches around affected palms to isolate the diseased palms, application of systemic fungicides like calixin through root feeding (2 g/ 100 ml), drenching the soil with fungicides (25 litres of calixin 0.1 %) and application of neem cake @ 5 kg/ palm/ year, along with the recommended dose of organic manures.

Pest management

Rhinoceros beetle (*Oryctes rhinoceros*)

The adult beetle damages the palm by boring through the unopened spindle, inflorescences and petiole, showing the typical 'V' shaped geometric cut pattern on the opened leaves. The IPM package for rhinoceros beetle includes extraction of the adult beetles using a beetle hook during the peak period of pest abundance (June-Sept.) from crown of all the palms, treatment of all possible breeding sites (farm yard manure dump, fallen coconut logs etc.) of the insect with 0.01% carbaryl (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 x 1011 spores of *Metarhizium anisopliae* fungus/m3 area of the breeding site of the pest, during monsoon period. Prophylactic measure include leaf axil filling of palms with 12.0 g naphthalene balls /palm covered with sand at 45 days interval. As prevention is better than cure, prophylactic leaf axil filling with 10.5 g (Approx. 4 Nos.) of naphthalene balls + sand is to be done at 45 days interval (Sadakathulla and Ramachandran, 1990). Application of neem cake or Marotti, *Hydnocarpus wightina* in powder form @ 250 g mixed with equal volume of sand in top most three leaf axils three times a year is effective prophylactic method (Chandrika *et al.*, 2001).

Red palm weevil (*Rhynchophorus ferrugineus*)

The pest damages the crown and bole regions of the palm, ultimately toppling the crown. IPM package for red palm weevil includes cleaning of palm crown periodically to avoid decaying of organic debris, proper cutting, splitting and burning of red palm weevil infested palms, treating of any wounds on the palm with coal tar + 1% carbaryl or 0.1% endosulfan, stem injection with 0.1% endosulfan/ dichlorvos or 1% carbaryl.

Prophylactic leaf axil filling with 20 g Phorate 10G in 200 g of fine sand during May, September and December or with 250 g marotti oil cake + 200 g of fine sand in leaf axils around spindle has been found to be effective. Trapping of floating population of the weevil can be done by setting up of pheromone traps. Synthesis of Ferrugineol, the aggregation pheromone, is being done at CPCRI (CPCRI,2005).

Leaf eating caterpillar (*Opisina arenosella*)

This pest feeds on the undersurface of the leaflets within silken galleries resulting in considerable reduction of photosynthetic area. 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*)

The mites suck the sap from the tender nuts resulting in appearance of elongated triangular white patch below the perianth, which in turn becomes pale yellow then brown with the advancement of the mite infestation (Sathiamma *et al.*, 1998). Severe infestation results in poor development of the nuts with reduced kernel weight and poor quality fibre and premature nut shedding (Nair, *et al.*, 2005). Management of this pest is possible by spraying of 0.004% azadirachtin or 2% neem oil, garlic and soap mixture during April-May, Oct.-Nov. and Dec.-Jan., in such a way that all mite infested palms in an area should be covered at the shortest possible interval (CPCRI, 2005).

White grub (*Leucopholis coneophora*)

White grubs damage the roots of palms and also tunnel into the bole and collar region of seedlings. IPM technology includes deep ploughing and digging of soil during pre- and post-monsoon period, collection and destruction of adult beetles during peak emergence period in May-June, setting up of the light traps to attract adult beetles and killing them, insecticidal application with phorate 10G @ 100 g/palm during May-June and September-October.

Coreid bug (*Paradasynus rostratus*)

The adults and nymphs of this pest suck the sap from buttons and developing nuts resulting in nut fall and malformation of the nuts. It can be managed by spraying the crown bunches and leaf axils with 0.1% carbaryl/ endosulfan (CPCRI, 2005).

Rodents (arboreal black rat *Rattus rattus* wroughtoni, burrowing rodents *Bandicota bengalensis*, B. indica, Gerbils Tatera indica) The rodents feed on the contents of tender nuts (3-6 months) resulting in nut drop and attack the unopened spathes, female flowers and leaf stalks. They also damage the seedlings and eat away the cabbage portion. Placing10 g of bromodiolone wax blocks 2 times at an interval of 12 days on the palm crown of one tree out of every 5 trees can control the arboreal black rat. For the bandicoots and gerbils, poison baits can be used by mixing 95 parts of raw rice, 3 parts of coconut oil and 2 parts of zinc phosphide (acute poison).

Scale insects and mealy bugs (minor pests)

Scale insect infestation is seen on leaves, button and rachillae while mealy bugs colonize on all tender parts like the bases of spear leaf, spadix, and inflorescence and inside the perianth of nuts. They can be managed by spraying 0.1% Fenthion/ Malathion on the infested leaves, buttons and rachillae (for scale insects) and 0.05% monocrotophos or 0.1% fenthion (for mealy bugs).

Termites (*Odontotermes obesus*)

Termites cause serious damage to nursery seedlings by feeding on the husk portions of the nuts and collar region resulting in wilting of central shoot. Drenching the nursery with 0.05% chlorphyriphos twice at 20-25 days interval is recommended for controlling the termites.

Nematode Management

The burrowing nematode (*Radopholus similis*) infested coconut seedlings exhibit at different stages of growth symptoms like yellowing, button shedding, reduction in leaf size and yield. Soil application of phenamiphos or phorate @ 25 kg ai/ha during Sept., Dec. and May completely eliminates *R. similis* in coconut nurseries (CPCRI, 2005).

Physiological and biochemical advances

The biochemical and physiological basis of seedling vigour in coconut and its relationship to productivity was explained. Leaf area contributes more towards the production of female flowers and nut yield. Spraying of 2 mm salicylic acid on the newly opened inflorescence was found to have beneficial effect in controlling button shedding. Coconut cultivars/hybrids were characterized based on fatty acid profiles for edible and industrial purposes (Naresh kumar *et al.*, 2000). Shelf life of coconut oil can be enhanced by storing it in brown bottles, plastic cans or clay jars with preservatives like tamarind (2%), common salt (1%) or citric acid (0.05%).Coconut hybrids such as Keraganga, Chandralaksha, Kerasankara and talls like Chandrakalpa and West Coast Tall were identified as relatively drought tolerant compared to the other varieties and hybrids. Gangabondam Green Dwarf, Malayan Orange Dwarf and Chandrasankara were found to be more susceptible to drought under sandy and sandy loam soil than laterite soil under rainfed condition (Rajagopal et al., 1990).

Value addition, pre and post harvest technology

An anti-buckling device or a coconut bunch support consisting of a GI strap to fix on the trunk and telescopic supports having GI pipes and rods and costing Rs.150/- was developed, to prevent buckling of heavy coconut bunches. A manually operated coconut-husking maehine has been developed with an out turn of 110 nuts/hr. A power operated semi automatic coconut dehusking machine has also been developed which can dehusk 500-600 nuts/ hour. A new processing method for preparing ball copra was developed. Preservation of fresh kernel upto 4 days is possible by dipping fresh kernels in 1000 ppm propionic acid for 60 minutes. Simple smoke free collapsible copra dryers have been developed in which about 1,000 coconuts/ batch can be dried in 24 hours. The cost of the dryer is in the range of Rs.7000/ to Rs. 25,000 depending on the capacity and the fuel used. A solar cum electric dryer with agriculture waste as third source of energy has been developed for copra drying with a capacity of more than 3000 nuts/ batch at a cost of Rs.40000/-. A technology for making snow ball tender nut (SBTN) from 8 months old coconuts has been developed. Along with the process, a suitable machine has also been developed for making SBTN. The cost of the machine is Rs 22,500/- (Bosco and Singh, 2005). A technology for the production of sweet coconut chips has been developed, by the process of osmotic dehydration, with a shelf life of 6 months. A tendernut punch and a cutter has been developed at a cost of Rs. 1,365/-. A process for the production of coconut chips with different flavours, medicated, spicy as well as instant coconut chips by microwave oven has also been developed. Process for the production of the fuel briquette with different composition of coir pith and shell powder of tender coconut has been developed. A fluid furnace using pith has been developed which can be connected to 400 nuts capacity copra dryer. A copra moisture meter has been developed to determine moisture content of copra, rapidly and accurately. An electronic tensiometer and an automatic irrigation system have been developed to optimize irrigation in coconut gardens.

Technology assessment and transfer

Statistical methods as applicable to plantation crops have been refined and analysis of data has been done using risk transformation methods. Economic analysis of arecanut based farming systems clearly indicated that intercultivation of vegetables, flowers, spices, tubers along with animal husbandry was more profitable than monocrop systems. Price spread analysis of coconut has also been done. The extension section of the Institute has, through different methods, encouraged technology adoption by farmers. Regular training programmes, participation in exhibitions, and technology transfer through mass media have facilitated the development of rural enterprises involving the application of improved processing technologies. Many farmers have successfully initiated production of chips, cultivation of intercrops and vermicomposting after undergoing training. The CPCRI website (http://www.cpcri.nic.in) hosted under NIC Server includes history, organization structure, achievements of various Divisions and Centres, future thrust, personnel, transfer of technology, training programmes and AICRP Palms. A new facility for the farmers for online registration of their planting material requirement is provided through the web site facility. Data warehousing of all the information on mandate crops is done. A touch screen monitor was installed at the ATIC for accessing information on coconut, arecanut and cocoa cultivation.

3. Future Thrust: Crop improvement

Enriching the gene banks and cryo-preservation of genetic resources, molecular techniques for finger printing and character tagging of germplasm accessions, breeding for tolerance to root (wilt) disease and drought.

Crop production

Studies on palm based farming systems, water management, Integrated Nutrient Management System involving organic manures, biofertilisers, PGPR's, Soil resource constraint using GIS, Carbon sequestration in different palm based cropping system.

Crop protection

Role of Phytoplasma in root (wilt) disease of coconut, Purification and characterization of Phytoplasma associated with palm diseases, sensitive diagnostic techniques for major diseases of palms. Analysis of residues of pesticides in palms and cocoa. Integrated Nematode Management in palm based cropping systems.

Physiology, Biochemistry and Post harvest technology

Studies on stress tolerance and production potential, development of labour saving machinery/ implements for field operations, product diversification and by product utilization.

Social sciences

The focus will be on refinement of experimentation techniques, database management for palms and cocoa, studies on marketing and developmental aspects of palms and cocoa, transfer of technology through training and agricultural technology information centre, and technology assessment and refinement through Institution-Village Linkage Programme. Socio economic aspects of technology adoption in palms and cocoa, cyber extension programmes and development of multilingual website portal on technologies and production of e-learning materials on various aspects would also receive adequate priority.

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