CPCRI

Regional Station, Kayamkulam

at a glance

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

REGIONAL STATION, KAYAMKULAM - 690 533, KERALA, INDIA

Technical Bulletin No. 80

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Phone: Head: 0479 2442004, PABX: 2442160, 2442104, KVK: 2449268

Fax: 0479 2445733, E-mail: headcpcri@yahoo.co.in

Published by:

Dr. George V. Thomas
Director
Central Plantation Crops Research Institute
Kasaragod - 671 124, Kerala

Text : Chandrika Mohan
P. Anitha Kumari
M. Shareefa
Jeena Mathew
K. Nihad
V.K. Chaturvedi

Editors : Regi J. Thomas
V. Krishnakumar
S. Kalavathi
A. Josephrajkumar
Merin Babu
P. Muralidharan

Cover design & Photographs : E.R. Asokan

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INTRODUCTION

The Central Plantation Crops Research Institute (CPCRI) was established during 1970 under the Indian Council of Agricultural Research (ICAR) by merging the erstwhile Central Coconut Research Stations at Kasaragod and Kayamkulam and the Central Arecanut Research Station at Vittal along with its five sub-stations. At present CPCRI has a country wide network of seven centres including the headquarters at Kasaragod and two Regional Stations at Kayamkulam and Vittal to cater to the research requirements of coconut, arecanut and cocoa under varying agroclimatic conditions. The Institute has the mandate to develop appropriate production, protection and processing technology of mandate crops. In addition, the Institute acts as the national repository for the genetic resources of the above crops and evolves varieties with desirable traits and high yield potential as well as tolerance to biotic and abiotic stresses.

HISTORY OF REGIONAL STATION

The Central Coconut Research Station (CCRS) at Kayamkulam was established during 1948 by the Indian Central Coconut Committee. The CCRS had its origin in the erstwhile Agricultural Research Laboratory (Office of the Plant Pathologist) started during 1937, with its headquarters at Kollam and a field station at Kayamkulam mainly to address plant protection problems in coconut. The ICAR took over the administrative control of CCRS from 1st April 1966 following the abolition of the Commodity Committees.

LOCATION

The Regional Station is located at Krishnapuram Village near Kayamkulam in Alappuzha District of Kerala State, midway between Ernakulam and Thiruvananthapuram, on the National Highway (NH 47). It is 6 km from Kayamkulam railway station and 46 km south of Alappuzha.

Total Area : 27.28 ha
Soil type : Sandy loam
Soil pH : 5.0 to 6.0
Latitude : 9° 8′ North
Longitude : 76° 30′ East
Altitude : 3.05 m above MSL
Mean temperature
Maximum : 33.0° C
Minimum : 21.4°C
Mean Annual rainfall : 2610 mm
Range of rainfall : 1900-3500 mm

The Regional Station comes under the administrative control of the Director, Central Plantation Crops Research Institute, Kasaragod and is managed by the Head. The current staff strength is:

Scientists : 11
Technical : 20
Administrative : 14
Skilled Supporting Staff : 30

The Krishi Vigyan Kendra (KVK) for Alappuzha district is functioning in this Regional Station. It is managed by one Programme Coordinator and supported by Subject Matter Specialists (6 nos.) in the field of Agriculture and Animal Husbandry as well as technical (4 nos.) and other administrative staff (4 nos.).

MANDATE OF THE REGIONAL STATION

- Investigate the etiology and develop appropriate management practices for diseases affecting coconut palm with special reference to root (wilt) disease.

- Conduct research on pests - insects, mites and nematodes and to develop suitable management strategies.

- Studies on nutritional and agronomic aspects to develop effective crop management practices. Develop compatible cropping system models for higher productivity and economic returns.

- Evolve high yielding coconut varieties with resistance/tolerance to root (wilt) disease. Production of quality planting materials of coconut for supply to farmers.

- Transfer of technologies developed by the Institute to farmers, extension personnel and other stake holders.

ORGANIZATION

With a view to fulfill the mandate of the Regional Station, research programmes are being undertaken in the following disciplines: Plant Breeding, Biotechnology, Agronomy, Horticulture, Soil Science, Biochemistry, Plant Pathology, Agricultural Entomology, Agricultural Extension and Agricultural Statistics.

ACHIEVEMENTS AND ACTIVITIES

During the past six and a half decades of its existence, this Regional Station has been engaged in various research programmes to solve pest and disease problems of coconut through a multidisciplinary approach. The results achieved have contributed to develop effective management strategies for coconut cultivation. Some of the major achievements of the Regional Station are enumerated below.

DISEASES OF COCONUT

ROOT (WILT) DISEASE

Root (wilt) disease poses a serious threat to the coconut production in southern states of India. The disease was reported from Erattupetta (Meenachil Taluk, Kottayam District) in 1882. Since then, the disease has spread in all directions. According to a survey of 1984-85, the disease occurred in a contiguous manner in 0.41 million hectare, in eight

Root (wilt) affected palm

southern districts of Kerala and sporadically in the remaining six northern districts of the State. The annual loss due to this non-lethal, debilitating disease was estimated to be about 968 million nuts and the monetary loss assessed in terms of loss in husk, copra yield and leaf on the basis of 1984 price index of

coconut was of the order of about Rs. 3000 million. According to the survey conducted during 1996-97 in Kerala, the average percentage of disease incidence is 24 with minimum incidence in Thiruvananthapuram District (2.1) and maximum in Alappuzha District (48). Recently the disease has been observed in the bordering districts of Tamil Nadu, Goa and Karnataka.

The palms of all ages are susceptible to the disease. The incidence occurs in all soil types and the spread is either contiguous or sporadic. The extent of decline in yield was 43% in palms of early stages and 74% in advanced stages, as compared to disease-free palms. Flaccidity, yellowing and necrosis of leaflets are the major visual symptoms of the disease.

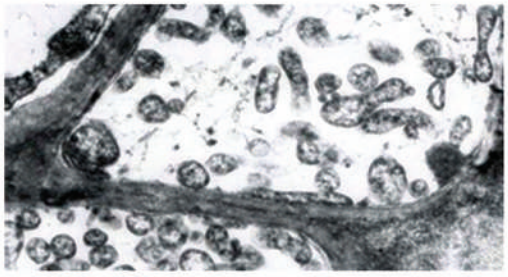
Leaflets showing flaccidity

Systematic investigations on the etiology have ruled out the role of any physiological/ nutritional disorders and also the role of biotic agents such as fungi, bacteria, viruses and nematodes. The causal agent of root (wilt) disease of coconut was established as phytoplasma by electron microscopy, transmission studies with vectors, dodder transmission, antibiotic therapy and light microscopic staining techniques. Successful transmission of the disease through *Stephanitis typica* (lace bug) and *Proutista moesta* (plant hopper) in

lace bug

plant hopper

insect proof conditions elucidated their potential as vectors of root (wilt) disease. The association of 16Sr XI group phytoplasma with root (wilt) disease has been established by PCR using custom designed primers and molecular characterization.



Phytoplasma in sieve tubes of root (wilt) diseased coconut roots

Phytoplasma from root (wilt) diseased palms was purified for preparation of phytoplasma specific antiserum. Using the phytoplasma specific polyclonal antisera, rapid and sensitive Enzyme Linked Immunosorbent Assay (ELISA) was standardized. This serodiagnostic test enables early detection of root (wilt) disease 6-24 months before the appearance of the visual symptoms. This technique is being used in screening disease-free palms for breeding purpose. The production of monoclonal

antibody specific to root (wilt) disease phytoplasma is in progress. Current research programmes focus mainly on the elucidation of factors involved in symptom variation, strategies to contain the disease in newly emerging areas and development of user-friendly, economic, precise and efficient nucleic acid based diagnostic techniques.

Integrated Approaches For Root (Wilt) Disease Management

An integrated approach in root (wilt) disease management is essential for ensuring sustained productivity in disease affected gardens. Management strategies encompassing integrated nutrient management, irrigation, intercropping, cutting and removal of disease advanced and unproductive palms and selection of quality planting materials were developed for ensuring sustainable production in disease endemic areas.

Soil health management strategies in coconut gardens for increasing the efficiency of crop husbandry practices

Soil health is the key component essential for the sustainability of crop husbandry practices in disease affected coconut gardens. Maintenance of proper soil health ensures optimum physico-chemical and biological properties. Depending on the soil reaction, suitable amendments are to be added. Application of lime or dolomite prior to fertilizer application is needed for the correction of soil acidity. Improving soil aeration is necessary for enhancing the nutrient trapping potential of roots as well as respiratory activity. Soil organic matter improves soil aggregation and aeration apart from serving as a nutrient reserve. Hence, application of FYM/vermicompost is an essential pre requisite for sound crop management strategies.

Integrated management practices for root (wilt) disease

Eradication of disease affected palms to contain the disease within the contiguously infected geographical limit has been very successful. Juvenile palms which contract the disease before the onset of flowering has a tendency to seldom yield and hence such palms have to be removed systematically and are to be replanted with disease-free quality planting materials.

An effective agro management package was developed for improving/sustaining the health and productivity of disease affected palms. It includes practices such as balanced fertilizer application, raising of green manure crops in the basins and incorporation, judicious use of organic manures, adoption of suitable soil and moisture conservation measures and irrigation, cultivation of compatible crops in the interspaces, and removal of disease advanced and uneconomic palms.

Pureria phasiolodes, Mimosa invisa and Calopogonium mucunoides, Vigna unguiculata are some of the ideal green manure crops. They produce around 20-25 kg fresh biomass which can supplement the organic matter to the soil and also N, P and K @ 130, 12 and 115 g, respectively.

Raising cowpea in basin

Adoption of plant protection measures against leaf rot and other pests and diseases of coconut palms also assume great relevance in maintaining the health of palms and disease management.

Dolomite application for correcting soil acidity

Application of lime or dolomite @ 1.0 kg/palm, 10-12 days prior to application of chemical fertilizers (to correct soil pH), application of recommended dose of chemical fertilizers (NPK @ 500:300:1000 g/palm/year) along with 1.0 kg magnesium sulphate ($MgSO_4$)/palm, application of any form of organic manure (@ 20 kg/palm), raising of green manure crops in basins and its incorporation are found to improve the growth and productivity of coconut palms. It also shortens the pre-bearing stage. Deficiency of boron, a micronutrient causing decline in growth and productivity, has been observed both for young and adult palms in many areas. In order to manage such palms, application of borax (to supply boron) @ 150 g for young palms and 250 g for adult palms in two split doses with other fertilizers is recommended.

Mulch the coconut basins with available materials such as coconut leaves, and remove weeds to conserve available moisture. Irrigate the palms with 200-250 l of water once in four days through hose irrigation (basin) or with 32-35 l of water/ palm/day through drip irrigation during the summer periods.

Mixed farming in coconut garden

Mixed farming by cultivating fodder crops such as Hybrid Bajra Napier grass, Guinea grass, and legumes as well as maintaining milch cows and recycling animal manures in root (wilt) disease affected gardens improve the soil physico-chemical and biological properties (enhanced microbial activity in soil) and consequently increase yield of coconut palms. It results in additional income from the dairy unit and a substantial increase in employment potential of the farm family. Installation of biogas plant provides light energy to farm family and slurry for use in cropping system. Azolla can also be raised in small pits lined with polythene sheets in coconut gardens adopting mixed farming to supplement the feed requirement of dairy animals.

Adoption of High Density Multi Species Cropping System (HDMSCS) involving annuals, biennials and perennials has been observed to enhance the net return from the disease affected coconut gardens. The crops selected should have small, medium and large canopy architecture and are to be planted in a systematic manner to exploit space in vertical and horizontal dimensions. Various types of vegetables, spices, tubers and fruit crops can be included under HDMSCS. It also plays a

HDMS Cropping System

pivotal role in sequestering the atmospheric carbon dioxide as soil organic carbon thereby opening up its potential for mitigation of climate change scenario. Organic residues available in coconut garden such as fallen leaves, spathes, inflorescences, residue from other inter/mixed crops etc. can be efficiently used as substrate for vermicomposting and thereby meeting the requirement of organic manure. *Heliconia stricta* cv. Iris Red was

Heliconia as intercrop

found to be a potential intercrop in coconut gardens with Land Equivalent Ratio and BCR of 1.4 and 3.9, respectively. The nutritional management practices for intercropping with Heliconia have been standardized. Intercropping Marigold (October to April) followed by Gomphrena (May to September) as catch crop in root (wilt) disease affected coconut garden supplied continuous market oriented flower production with a mean BCR of 2.62.

Marigold as intercrop

Breeding for resistance/tolerance to coconut root (wilt) disease

As root (wilt) disease cannot be controlled by conventional plant protection measures, cultivation of resistant varieties is the most ideal and practical method for its management. Eighty four cultivars and sixty eight hybrids from the coconut germplasm maintained at CPCRI, Kasaragod were screened during 1961-1988 at CPCRI, Regional Station, Kayamkulam and the studies indicated that none of the varieties/hybrids had satisfactory level of resistance to coconut root (wilt) disease. Hence, a 'hotspot breeding' programme for resistance/ tolerance to coconut root (wilt) disease was launched during 1988. Evaluation studies carried out during the past 20 years have culminated in the release and notification of two varieties and one hybrid of coconut for cultivation in the root (wilt) disease prevalent tracts.

Varieties / hybrid released

Kalparaksha (Selection from Malayan Green Dwarf): This variety was identified as resistant to root (wilt) disease during 2004. Kalparaksha yields 88 nuts/palm/year with 2.85 t/ha of copra and oil yield of 1.85 t/ha.

Kalparaksha

It is remarkable not only for its high yield but also suitable as a tender nut variety. It has got more quantity of tender nut water (275 ml per nut) which is sweet and tasty. Kalparaksha was released as a resistant variety to coconut root (wilt) disease by Central Variety Release Committee during July 2008.

Kalpasree (Selection from Chowghat Green Dwarf): This is comparatively short statured among all dwarf varieties of coconut. In an intensive survey carried out in 'hot spots' of root (wilt) disease, it was found that 75% of CGD palms were disease-free, whereas, the West Coast Tall (WCT) palms standing in the same plots had disease incidence to the extent of 80% or more indicating that CGD variety has higher level of resistance to coconut root (wilt) compared to WCT. Kalpasree yields 55 nuts/palm/year, producing copra yield of 0.94 t/ha and oil yield of 0.55 t/ ha. The kernel has good cooking qualities and oil content of 66.3%. Tender nut water (170 ml per nut) is also sweet and tasty. Because of the small crown size, this variety can be grown at a distance of 6.5 x 6.5 m. It is more suitable for cultivation in homestead gardens. But the major disadvantages of this variety are small size of the nut and less copra content. However, like other dwarfs, caution is advised for the control of red palm weevil. Kalpasree was released as a variety suitable for cultivation in the root (wilt) disease prevalent tracts by the Central Variety Release Committee during March 2012.

Kalpasree

Kalpa Sankara (CGD X WCT): This hybrid attains a height of around 3.80 m at 13 years of age. It is early flowering (four years after planting) in nature. The hybrid palms gave a ten year average yield of 84 nuts/palm/year, copra yield of 2.50 t/ha and oil yield of 1.69 t/ha. Though, after 18 years of planting, 67.7 % of these hybrids showed symptoms of root (wilt) disease, the disease-free hybrids gave an average yield of 107 nuts/palm/year, whereas, the disease-affected hybrids gave 72 nuts/palm/year. With regard to resistance to root (wilt) disease, hybrid palms were intermediate between parental varieties (CGD and /CT). Tender nut water (375 ml per nut) is

sweet in taste. This hybrid was released for cultivation in the root (wilt) prevalent tracts by the Central Variety Release Committee during March 2012.

Kalpa Sankara

Evaluation trial involving dwarfs and hybrids

A new screening trial was initiated during 2009 to evaluate the reaction of dwarfs such as MGD, MOD and MYD and hybrids such as CGD x MGD, MYD x WCT, MGD x WCT, CGD x WCT along with WCT to root (wilt) disease of coconut. Observations after three years of planting showed that three palms of MOD and the hybrid involving MYD took up the disease indicating their higher level of susceptibility to the disease. Root (wilt) disease incidence was comparatively less in MGD, CGD x MGD and MGD x WCT. In terms of hybrid vigour (for number of leaves, leaf production rate and girth at collar region) MGD x WCT and MYD x WCT are superior compared to CGD x WCT.

Recurrent selection programme

Selfing / *inter se* mating of selected disease-free WCT palms were initiated during 1991-92 for developing an improved WCT variety with higher level of disease resistance through recurrent selection. A total of 1,250 selfed/ *inter se* mated progenies of disease-free mother palms were planted during 1994-96 at CPCRI, Regional Station, Kayamkulam and selections were made within the progenies. Initially, a total of 80 disease-free progenies were selected based on visual appearance and finally 40 selfed/*inter se* mated progenies were selected after confirmation by ELISA test. Subsequently crossing programme was carried out during 2010-11 on the 40 selected palms for producing second generation selfed/*inter se* mated progenies. A total of 172 progenies (second generation) have been planted and further evaluation will be carried out to improve the population.

LEAF ROT

Leaf rot

Leaf rot, a disease of fungal etiology, occurs superimposed on about 65 per cent of root (wilt) affected palms. Extensive studies have clearly established that leaf rot is a disease of fungal complex and *Exserohilum rostratum* and *Colletotrichum gloeosporioides* are the main pathogens.

A series of field trials conducted led to the development of a very effective, economic, environment friendly and easy method that integrates leaf rot disease management with pest management.

• Cut and remove rotten portions of the spindle and the adjacent two leaves.

• Pour either Contaf-5EC (Hexaconazole) 2 ml or Indofil M-45 (Mancozeb) 3g in 300 ml of water, around the base of the spindle leaf of the affected palm. Alternatively, 50 g of talc-based formulation of the bio-control agent *Pseudomonas fluorescens* or *Bacillus subtilis* (singly or in consortium/combination) mixed in 500 ml water may be applied. Palms in the early stages of disease will recover totally with two or three applications. Palms in the advanced stages (with an index of more than 50%) may take three years to recover fully.

Root (wilt) affected palm superimposed with leaf rot disease

• Since the leaf rot affected palms are prone to pest attack, filling the youngest three leaf axils with a mixture of 250 g powdered marotti/neem cake with equal quantity of sand or placing naphthalene balls (12 g/ palm) and covering them with sand may also be adopted.

In disease endemic areas, prophylactic treatment with the above mentioned fungicide/bio-control agent along with leaf axil filling against insect pests may be adopted twice a year during April-May and October-November.

BUD ROT

Bud rot affected palm

Bud rot disease caused by the fungus *Phytophthora palmivora* occurs in all coconut growing tracts. Disease incidence is severe during monsoon and young palms are mostly susceptible.

Integrated management strategy involves the removal of disease advanced palms, fungicide treatment, field and plant hygiene, integrated nutrient management and control of pest infestation especially that of rhinoceros beetle. The infected rotten crown tissues have to be removed before applying fungicide. The cut spindle portion may be treated with mancozeb solution (5g in 300 ml water/palm) followed by placing two perforated sachets containing mancozeb (5 g in each sachet) in the inner most leaf axils.

STEM BLEEDING

The disease caused by the fungus *Thielaviopsis paradoxa* is characterized by dark gummy exudation from vertical growth cracks at the lower portion of the trunk. In the advanced stage of the disease, the affected palms show yellowing, drooping and drying of outer whorl of leaves, tapering of trunk and reduction in

crown size. Based on the aerial symptoms, a method to index the disease severity has been evolved.

Stem bleeding

The effective control measures include chipping of the affected bark and application of systemic fungicide 5% Calixin (Tridemorph) followed by coal tar and root feeding with Calixin (5%). Providing adequate drainage during monsoon and irrigation during summer reduces the incidence of the disease. Swabbing the affected portion of the trunk with a paste of *Trichoderma* talc based formulation has been found effective in managing the disease. Application of neem cake enriched with *Trichoderma* @ 5 kg per palm during post monsoon period is recommended.

PESTS OF COCONUT

Proper identification of damage symptoms of pests and timely adoption of various integrated management strategies would be of paramount significance for improving palm health and enhancing coconut productivity.

RHINOCEROS BEETLE (*Oryctes rhinoceros*)

Rhinoceros beetle or black beetle attacks coconut palms of all growth stages. Adult beetle bores into the unopened spindle leaves and spathe causing characteristic "V" shaped geometric cuts on leaves and round to oblong holes on spathes. Growing point of seedlings and juvenile palms gets twisted, malformed and stunted by feeding injury. Extrusion of chewed up fibre at the bore hole is one of the characteristic symptoms of identification.

Rhinoceros beetle (inset) and infested leaves

Management package consists of mechanical extraction of beetle using a hook from the infested palm, maintenance of farm hygiene including disposal of possible breeding grounds, treating breeding sites with green muscardine fungus, *Metarhizium anisopliae* @ $5x10^{11}$ spores /m^3 as well as incorporation of the plant, *Clerodendron infortunatum* which disrupts metamorphic moults.

Clerodendron infortunatum

GMF infected *Oryctes* grub

Filling the youngest three leaf axils with a mixture of 250 g powdered marotti/neem cake with equal quantity of sand or insertion of chlorpyrifos dust or chlorantraniliprole

granules or fipronil granules @ 6 g mixed with 250 g sand or placing naphthalene balls (12 g / palm) and covering them with sand thrice a year is an effective prophylactic treatment. Placement of insecticides viz., chlorantraniliprole granules or fipronil granules @ 6 g in perforated polythene sachets on topmost three leaf axils is also found effective.

Release of *Oryctes rhinoceros* nudivirus (OrNV) infected beetles @ 10-12 beetles / ha and installation of pheromone traps (PVC pipe of dimension 11 cm diameter and 1.5 m height) using pheromone - ethyl 4-methyl octanoate (Oryctalure) @ 1 trap/ha are the other IPM strategies for the control of adult beetles. These technologies are quite successful in area-wide and community-based approach in pest management.

RED PALM WEEVIL

(Rhynchophorus ferrugineus)

Red palm weevil infested toppled coconut palm

Red palm weevil, a concealed tissue borer, is one of the key pests of coconut. Feeding on the growing point by grubs results in death of the palm. The presence of holes on the stem, oozing out of brown viscous fluid through holes, extrusion of frass, wilting of inner leaves, splitting of leaf bases and gnawing sound produced by feeding grubs enable the detection of pest infestation. Chlorosis of mid-whorls and crown toppling are the key diagnostic features.

Red palm weevil

Grubs of red palm weevil

Scouting and monitoring the damage by close examination and routine checkup for red palm weevil infestation is mandatory on young coconut plantations. Complete destruction of dead palms and all pest stages in the immediate vicinity has to be undertaken as part of field sanitation. Phyto-sanitation includes avoiding injuries to palms and treating with fungicides/insecticides on cut wound if any, leaving behind 1.2 m petiole while cutting leaves from the trunk and prophylactic leaf axil filling as recommended for black beetle management.

As curative treatment, infested palms could be treated with imidacloprid (0.02%) or spinosad (0.013%) or indoxacarb (0.04%). Synergistic interaction of imidacloprid (0.002%) along with entomopathogenic nematode, *Heterorhabditis indica* is being field investigated. Trapping of red palm weevil using aggregation pheromone lures i.e., ferrugineol in food baited bucket traps @ 1 trap/ha forms an important component in integrated pest management (IPM) strategy. Servicing of food

baits once in six days is necessary and avoid placing traps in gardens with juvenile palms or intercropping with tall intercrops (banana).

ERIOPHYID MITE (*Aceria guerreronis*)

Eriophyid mite colony

Eriophyid mite infests button during early stages of growth soon after pollination and symptoms appear about one month after initial colonization as white longitudinal patches or triangular yellow patches near the perianth. As nuts grow, these patches turn brown and longitudinal fissures and wartings appear on the nut surface. Drying and shedding of buttons and young nuts are noticed in severe infestation.

Eriophyid mite infested coconut

An integrated management strategy with need-based application of botanical pesticides either by spraying or root feeding and adequate nutrient management of affected palms is currently recommended for the management of the pest. Plant protection includes spraying 2% neem oil-garlic-soap emulsion or azadirachtin 10000 ppm @ 0.004% on young bunches or root feeding of neem-based pesticides containing Azadirachtin 5% (7.5 ml + 7.5 ml water) or azadirachtin 1% (10 ml + 10 ml water) thrice a year during January, April and September. Spraying of palm oil (200 ml)-sulphur (5g) emulsion in one litre water along with detergent (10-15 g) on mite infested young bunches after pollination was found effective in suppression of mite damage. The potential of the acaropathogenic fungus, *Hirsutella thompsonii* as an effective biocontrol agent against mite is currently being investigated in the field.

Hirsutella thompsonii

LEAF EATING CATERPILLAR (*Opisina arenosella*)

Coconut leaf eating caterpillar (inset) and infested garden

Diagnostic symptoms of infestation are the presence of galleries on the lower surface of leaves with live or dead stages of the pest and the upper epidermis intact presenting a scorched up appearance. Damage to the leaves affects the photosynthetic efficiency of the palm, leading to yield loss of about 40% and in addition renders the leaves unsuitable for other purposes.

An integrated management package including cutting and burning the heavily infested and fully dried outermost 2-3 leaves and release of larval/ pupal parasitoids such as *Bracon brevicornis*, *Goniozus nephantidis* and *Brachymeria nosatoi* are to be adopted. The larval parasitoid *G. nephantidis* (Bethylidae) is

Bracon brevicornis

Goniozus nephantidis

released if the pest is at 3rd larval stage or above @ 20 parasitoids/palm and *Bracon brevicornis* (Braconidae) @ 30 parasitoids/ palm. In severe sporadic outbreaks, spraying dichlorvos (0.05%) or malathion (0.05%) on the under surface of leaves can be done to bring down the population. If insecticide spraying is undertaken, waiting period of 21 days is recommended for release of parasitoids. Proper irrigation and adequate fertilizer application should be done to rejuvenate the pest-affected palms.

WHITE GRUB (*Leucopholis coneophora*)

White grubs are major pests of coconut palm mostly confined to sandy loam soil tracts of Kerala and Karnataka. Grubs feed on roots of coconut palm as well as other intercrops like cassava, yams, banana, vegetables etc. In nursery seedlings, the grubs feed on tender roots and also tunnel into the bole and collar regions resulting in the drying of the spindle leaves followed by gradual death of the seedlings. In older coconut plantations, continuous infestation by the grubs results in yellowing of leaves, premature nut fall, delayed flowering, retardation of growth, tapering of crown and reduction in yield.

Coconut white grub

Deep ploughing and digging of the soil during pre and post-monsoon periods for exposing grubs to predators are recommended. Collection and destruction of adult beetles during emergence period (May-June) was found effective. Drenching the palm basin with chlorpyriphos @ 0.1% (7 ml/litre of water) @ 14 litre/palm during June and September and incorporation of neem cake @ 5 kg/palm/year controls the pest.

COREID BUG (*Paradasynus rostratus*)

Coreid bug

Adults and nymphs feed on the buttons and young nuts causing shedding of buttons and malformation of mature nuts. In many cases, the infested nuts show crinkling, gummosis and become barren. In addition to coconut, the pest also attacks guava, cashew, neem and cocoa.

Coreid bug infestation symptoms on button and mature nut

Phytosanitary measures like crown cleaning and plantation sanitation are very important in the management of coreid bug. Spraying the infested palms with neem oil (0.5%) or carbaryl (0.1%) on female flowers and young bunches (up to five months old) two times a year during May and September is recommended for control of the pest in endemic areas.

SUCKING PESTS: They include scales, mealy bugs, white flies and aphids which cause negligible damage and are suppressed by natural enemies. Application of neem oil (0.5%) or dimethoate (0.05%) on need based situation is recommended for the management of sucking pests.

NEMATODE: Thirty-nine species of phytoparasitic nematodes have been recorded from the root zone of coconut including the burrowing nematode (*Radopholus similis)* that causes heavy damage on coconut seedlings.

Feeding by *R. similis* causes brown lesions on the infected roots impairing the nutrient uptake potential of the seedlings. Continuous feeding leads to the production of weaker seedlings in nursery. It is usually dispersed through root material and by poorly sanitized bare root propagative planting material.

Remove old infected roots of coconut seedlings at the time of transplanting. Intercrop such as banana (most-preferred host) is not recommended near the nursery. Planting of marigold along the borders can act as trap crop and reduce the infestation. Apply neem cake (3 kg/nursery bed) at the time of preparation of coconut nursery bed. Changing the nursery site every year is recommended to avoid nematode build up and thereby to reduce damage by nematodes. Biocontrol agents such as *Paecilomyces lilacinus*, *Pasteuria penetrans*, *Trichoderma viridae*, *Trichoderma harzianum* and arbuscular vesicular mycorhizae were found effective in reducing the damage caused by burrowing nematodes.

TRANSFER OF TECHNOLOGY

Technologies developed at the Institute are effectively disseminated to the extension functionaries and farming community through various approaches and methods. Participatory approaches to integrate, refine and disseminate coconut technologies through Community Based Organizations (CBOs), Clusters and Farmer Field Schools (FFS) were proved as highly successful for large scale adoption. Various methods for technology transfer include training programmes, front line demonstrations, ICT enabled programmes like video conferencing, popularization through media and extension literature, diagnostic field visits, advisory services through Institute visits, helpline services, postal and internet facilities etc.

COMMUNITY BASED APPROACHES IN TECHNOLOGY TRANSFER

The station has successfully implemented many extension projects in farmers' field on (a) Participatory technology transfer on management of root (wilt) disease of coconut, (b) Poverty reduction in coconut growing communities through sustainable livelihood approaches, (c) Area wide community adoption approach for biocontrol of coconut pests, (d) Female farmers oriented programme, and (e) Cluster/community approaches in increasing productivity and income from coconut through recommended technologies and diversification of products in collaboration and with financial assistance from national and international agencies.

Diversification of crops and coconut-based enterprises implemented through Community-Based Organizations (CBOs)

Farm level multiplication of GMF

emerged as the most effective strategy for improving the quality of life of the marginal coconut farmers - both in terms of income as well as food and nutritional security. The CBFS strategy adopted through a participatory community approach not only increased income but also contributed to the strengthening of individual as well as group capacities, improvement in CBOs' ability to mobilize local resources and the social and economic empowerment of CBO members, especially women.

TRAINING PROGRAMMES

The regional station offers institutional and off campus training programmes on various aspects of coconut cultivation with special emphasis on plant protection to various levels of functionaries such as scientists, university staff, extension personnel, farmer organizations, SHGs, local representatives, students and youth. Besides, training programmes are also conducted on selected topics on request from individuals and organizations. The station is also keen in attracting students and youth to agriculture through orientation programmes at Institutional and School level.

Off campus training

FFS on IPM of Rhinoceros beetle

FRONT LINE DEMONSTRATION PROGRAMMES, ASSESSMENT AND REFINEMENT OF TECHNOLOGIES

Front line demonstration programmes on selected technologies relating to INM, IPM and IDM of coconut with special emphasis to root (wilt) disease management are being organized for convincing the farmers about the viability of the technologies under farmers' field conditions and to obtain proper feedback from them on the constraints in adoption of the recommended technologies and further refinement.

FLD on coastal sandy soil management

ICT ENABLED PROGRAMMES

Cyber extension activities utilizing the video conferencing facility is effectively utilized for conducting interface programmes on value addition of coconut, IPM of rhinoceros beetle, coastal sandy soil management and organic farming in coconut for various stakeholders at regular intervals. This could enable interaction of farmers at remote villages with the subject matter specialists of the institute and other centres thereby reducing the time, effort and cost in transfer of know-how from lab to field.

FARM ADVISORY SERVICES

Diagnostic field visits: The station regularly arranges visit of multidisciplinary diagnostic team on request from farmers and extension personnel and suggests remedial measures for field problems.

Farm advisory visit

Institute visit by farmers and other clients: The station promptly offers guidance to farmers, students, entrepreneurs and SHGs etc., who visit the station for technical advice pertaining to coconut production, protection and processing.

UTILIZATION OF MEDIA AND OTHER EXTENSION METHODS

The following activities are regularly being taken up to effectively utilize various media and methods of extension for effective TOT in coconut:

- Technology dissemination through news papers, farm journals and radio, publication of extension literature, Scientists-Extension-Farmer - Entrepreneur Interface, Kisan Melas, Exhibitions, Agricultural Seminars.

PRODUCTION OF QUALITY COCONUT SEEDLINGS

The CPCRI, Regional Station, Kayamkulam is also involved in the production of quality coconut seedlings for distribution among farmers

Coconut seedlings in nursery

of root (wilt) prevalent tracts. During the twenty year period (1991-2012), a total of 92,000 seedlings including different cross combinations of WCT, CGD and COD were produced utilizing the disease-free mother palms selected in disease-hotspots. About 80,000 seedlings were distributed to farmers belonging to the eight root (wilt) disease

Seed garden at CDB Farm, Neriamangalam

prevalent districts of Kerala State. The Station has also established seed gardens for production of root (wilt) disease resistant / tolerant seedlings. In order to supply quality planting materials, seed nuts are collected from high yielding and disease-free mother palms located in the 'disease hot spots'. Typical mother palms of CGD (270 nos.), COD (40 nos.) and WCT (125 nos.) are identified in the disease-endemic areas and they are further serologically tested to confirm the disease-free status. Based on the facilities for production of quality coconut seedlings and after assessing the quality of mother palms, the Regional Station has been accredited by the National Horticultural Board (NHB) from June 2011. The station is also engaged in the production of coconut hybrids (CGD x WCT) in a limited scale.

KRISHI VIGYAN KENDRA - ALLEPPEY

The Krishi Vigyan Kendra (KVK) of Alappuzha (Alleppey) District is functioning at CPCRI, Regional Station, Kayamkulam since October, 2000.

KVK strives to test, demonstrate and popularise viable and feasible location specific technologies in farming and allied enterprises among the farming community including rural youth, women and men self help groups, and extension officials. For turning this into reality, interventions through On Farm Testing (OFTs), Front Line Demonstration (FLDs), and trainings on various subjects like crop production, soil health management, horticulture, plant protection, food processing, animal husbandry, fisheries, and vocational topics are undertaken with farmer participation to convince the farming community about the benefits of proven technologies in field situations. During a decade of its activities, the KVK has tested about 60 technologies and demonstrated about 75 technologies. As high as 1600 trainings in various categories (on-campus,

Demonstration on the use of drum seeder

off-campus, sponsored, and vocational) have been conducted benefitting more than 40,000 farmers, rural youth and entrepreneurs. It also functions as the knowledge-cum-resource centre of the district in Agriculture and allied activities by making technology information, technology products and technology services available to farmers.

Integrated duck-fish farming system

Other than the mandated activities, many external funded projects are being implemented by KVK. The major ongoing projects are:

NATIONAL INITIATIVE ON CLIMATE RESILIENT AGRICULTURE (NICRA)

The prestigious project is initiated and funded by ICAR and coordinated by CRIDA, Hyderabad. In Alleppey district, the project is implemented in Muttar village of Kuttanad taluk from 2011 onwards, mainly focussing on integrated farming system as a climate adaptation and mitigation strategy, and demonstrating diversification and integration of food production activities in the region.

SOIL BASED PLANT NUTRIENT MANAGEMENT PLAN FOR AGRO-ECOLOGICAL SYSTEMS OF KERALA

This is a state wide network project funded by Department of Agriculture and co-ordinated by the State Planning Board. In this project, 3645 soil samples from 24 panchayaths and one municipality of Alleppey District are analyzed for macro and micro nutrients. The data generated is to be utilized for preparing the nutrient management plan for the respective areas.

DOCUMENTATION OF FARMER INNOVATIONS IN ALLEPPEY DISTRICT

This project funded by State Planning Board aims to document the farmer innovations in Agriculture with the objective of validating them if required, and bringing them to the mainstream for the benefit of the farmers.

"FRIENDS OF COCONUT TREE" TRAINING PROGRAMME

Six day residential training programme "Friends of coconut tree" sponsored by Coconut Development Board is conducted by the KVK for developing skilled persons for harvesting and undertaking plant protection operations in coconut. The trainees are also exposed to aspects of skill and personality development, physical fitness and thrift management aspects.

FUTURE THRUST

The Regional Station will focus on developing high yielding varieties of coconut having resistance to various pests and diseases. Simultaneously effort will also be taken to refine the pest and disease management strategies to make them economic, ecologically safe and farmer friendly. Research programmes for enhancing nutrient use efficiency through Nutrient Decision Support System will be given emphasis. Participatory approaches to transfer the recommended technologies to farmers through community based organizations will also be the prime thrust

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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