Technical Bulletin No. 55

Integrated Pest Management in Coconut

Central Plantation Crops Research Institute
(*Indian Council of Agricultural Research*)
Regional Station, Kayamkulam, Krishnapuram P.O.
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Integrated Pest Management in Coconut (2009)
Technical Bulletin No. 55
Central Plantation Crops Research Institute,
Regional Station, Kayamkulam, Kerala, India. 20p.

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

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SEPTEMBER - 2009

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Cover photographs
Red palm weevil, Rhinoceros beetle,
Eriophyid mite

Printed at
Niseema Printers
Kochi - 18. Ph : 0484-2403760

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INTEGRATED PEST MANAGEMENT IN COCONUT

The coconut palm *Cocos nucifera* L. is one of the traditional crops in India. It provides food, shelter, fuel and employment to millions of people in the tropics. Coconut palm is prone to infestation by a large number of pests. The major pests are the rhinoceros beetle, red palm weevil, leaf eating caterpillar, eriophyid mite and the white grub. Pests like coreid bug, scale insects, mealy bugs and slug caterpillars cause considerable damage to the crop in certain localities. Rodents are the most important non-insect pests in the coconut plantations.

Damage to coconut leaf by rhinoceros beetle

Fresh damage on spindle leaf by rhinoceros beetle

Rhinoceros beetle *Oryctes rhinoceros* Linnaeus (Coleoptera: Scarabaeidae)

Oryctes rhinoceros commonly known as rhinoceros beetle or black beetle is a major pest of coconut in all the coconut growing regions of the world. The beetle is a major pest of oil palm (*Elaeis guineensis*) and also infests other palm species like date palm (*Phoenix dactylifera*) and palmyrah (*Borassus flabellifer*).

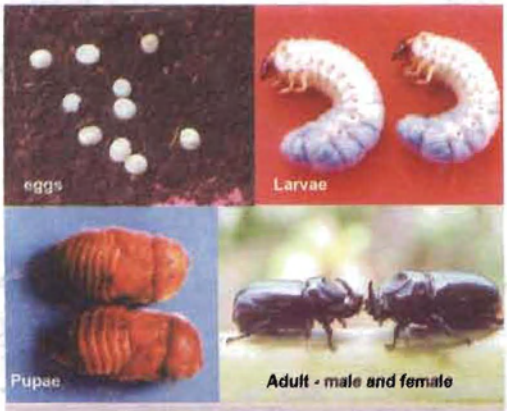
Damage and symptoms:

The robust adult beetles cause damage to palms of all age groups by boring into the unopened spindle leaves and spathes and chew off the soft internal tissues. As the pest bores deeper into the host it pushes out the chewed up tissues as fibres, which are seen extruding from the entry points. Once these injured spindles open up, the green leaves present a geometric 'V' shaped cut pattern. The damage to inflorescence is seen as round oblong holes on the spathes which soon dry up resulting in complete loss of nuts in the affected bunch. Attack on young seedlings results in stunted growth and delayed flowering. Black beetle infestation has to be considered serious as the damage

done by this pest provides egg laying sites for another lethal pest *viz*., red palm weevil and for entry of fungal pathogens.

Bioecology:

The adult is a stout black beetle 35-50 mm in length and 14-21 mm in breadth. It has a cephalic horn, which is longer in males. The pygedium has reddish brown hairs in the female. The beetle breeds in the



Life stages of rhinoceros beetle

decaying organic matter like cattle dung, compost pits, dead and decaying coconut logs, saw dust, coir pith, rotting paddy straw, sugarcane waste *etc*., where the adults lay eggs and complete the larval and pupal stages. The grubs are creamy white in colour with the body strongly arched dorsally (C-shaped). Grub period is about 130 days with three instars. The pupal period varies from 20-29 days. Adult longevity is 3 - 4 months. Adults are active during night and remain hidden during day time in the feeding or breeding sites. Average fecundity per female is 108 eggs.

Pest occurs throughout the year with peak adult emergence during June-September. Population of the beetle was observed to be high in young plantations with multiple breeding sites and in areas receiving high rainfall.

Rhinoceros beetle breeding grounds - dead coconut stumps and logs

Management:

Since the pest is an active flyer, Integrated Pest Management (IPM) strategies adopted on a community basis are essential to bring an effective control of *O. rhinoceros* population. The major components of IPM package consist of

sanitation, mechanical, chemical and biological methods.

Sanitation method: The dead and decaying coconut logs and other organic debris in the vicinity of coconut plantations may be properly disposed off, since this act as prolific breeding grounds of the beetle.

Mechanical control: This method involves periodic examination of the palm crown and removing the adult beetle by means of a metal hook during peak periods of pest abundance (June-September). The bore hole has to be filled with a mixture of mancozeb and sand @ 3g/1kg.

Prophylactic method: Filling the young leaf axils of the palm with repellent material is the prophylactic method. Application of powdered oil cakes of neem (*Azadirachta indica* A. Juss.) or marotti (*Hydnocarpus wightiana* Bl.) @ 250g mixed with equal volume of sand, into the top most three leaf axils around the spindle leaf thrice a year during May, September and December is recommended as a prophylactic measure against rhinoceros beetle and red palm weevil. Placement of naphthalene balls in the leaf axil at the base of spindle leaf @ 12g/ palm (3-4 numbers) and covering them with sand to prevent quick evaporation provide good protection against the pest for 45-60 days.

Biological control: This method is the most important component in the IPM of *O. rhinoceros*. Two potential microbial agents *viz.*, green muscardine fungus (*Metarhizium anisopliae*) and *Oryctes rhinoceros* virus (OrV) cause disease to the immature and adult stages of the beetle. Use of these microbial control agents is advantageous because they are relatively host specific, does not cause environmental pollution, safe to humans and are compatible with other control methods.

Metarhizium anisopliae (Metchinkoff) Sorokin is an entomopathogenic fungus which kills the pest in conditions of low temperature and high humidity. The disease caused by the fungus is called green muscardine disease because of the green color of its spores. *M. anisopliae* var. *major* (spore size 10-14 µm) is highly infective and widely used for the control of *O. rhinoceros*. The fungus gains entry into the body of the host through the cuticle region. The pathogen is highly virulent and produces epizootics in the grub population in the breeding material. All stages of the host excepting the eggs are mycosed. Death and mummification occurs within 15-20 days after infection. A white mycelial mat appears externally, turning green few days later because of the production of spores.

Grubs of *O. rhinoceros* infected with *Metarhizium anisopliae*

Mass multiplication of the fungus: Mass multiplication technique for *M. anisopliae* using coconut water as the medium was developed in CPCRI. The fungus can also be grown on rice, grain millet, dried cassava chips, crushed maize, rice bran *etc*. Farmers themselves can adopt this method with some training on the culturing of the fungus.

Mass production in coconut water

1. Take 25-30 ml coconut water from mature nuts in flat-sided glass bottles, plug the mouth with cotton and sterilize them properly using autoclave or pressure cooker and transfer *M. anisopliae* spores into the bottles under asceptic conditions.
2. Incubate the bottles at room temperature or 28± 2°C by keeping them flat on a rack. After 25-30 days when the green coloured spore mass fully cover the surface, mix the spore mass in sterile water and spray it on the rhinoceros beetle breeding sites @ 5 x 10^{11} spores/m^3 of breeding area

The fungus infests the grubs present in the breeding grounds and the spores of the fungal pathogen will survive in the breeding material for longer period up to two years.

***Oryctes rhinoceros* virus (OrV):**

The OrV infects both beetles and grubs. The virus enters the host only orally through contaminated food. The pathogen is very effective as it kills the grubs in 15-20 days of infection. The infection by OrV results in reduction of the longevity of the beetle by 45% and a reduction in fecundity of the beetle by 95%. Introduction of the pathogen to the natural habitat of the pest causes epizootics in the pest population and leads to significant reduction in the larval population in the breeding sites and resultant reduction in the beetle damage on the coconut palms.

***O. rhinoceros* grubs (OrV infected and healthy) dissected to show OrV symptom - white fluid filled mid gut**

The infected larvae become less active and stop active feeding. As a result of virus multiplication in the mid gut epithelium, fat body disintegrates and haemolymph content increases. This causes translucency in the abdominal region which is an important exopathological symptom of the OrV infection. In certain cases increased turgor pressure inside the gut causes extroversion of the rectum. The healthy grubs on the other hand are active and feed vigorously and a dark midgut line is seen externally. On dissection, the infected grubs show midgut filled with white fluid where as in the healthy grubs it is filled with dark coloured food material.

Infected beetles do not show any external symptoms of disease unlike the grubs. The diseased beetles are capable of flying and defecate infective virus in the feeding and breeding sites. Thus the beetles themselves are the good disseminators of the virus. The infected beetles disseminate the virus through their faecal matter into the surroundings after 3-9 days of inoculation at the rate of 0.3 mg virus/adult/day.

To confirm the presence of the virus infection, a technique by staining the mid gut epithelium or midgut fluid with Giemsa stain has been developed. The midgut epithelial smear stained with 3% Giemsa stain for 30-40 minutes, show pink coloured enlarged nucleus (18-20 µm) with vacuoles under light microscope, where as in healthy samples the nucleus will be of 7.5–12.5 µm in size. The viral particles can be seen only under electron microscope.

Mass production of the virus: The OrV is mass multiplied and maintained in the laboratory on live grubs. The OrV infected grubs are dissected, the swollen midgut is taken out and the viral suspension of the midgut is prepared by grinding with phosphate buffer (*p*H 8.0). This viral inoculum is fed to the healthy grubs to induce infection. The inoculated grubs are reared on sterilized food (cow dung, coir pith or saw dust) and are moistened sufficiently. The development of OrV infection is to be monitored in the inoculated grubs and the whole procedure of inoculation of healthy grubs is repeated to maintain the viral culture in the host. The grubs showing external symptoms, *ie.*, translucent gut or extroversion of rectum has to be dissected immediately; otherwise secondary infection with other pathogens like *Pseudomonas* sp. *etc.* takes over and destroys the OrV infection. The OrV infected grubs after developing the symptoms can be stored in the deep freezer at -40°C indefinitely retaining the virulence of OrV.

Field dissemination of OrV: The simplest and best practical method of dissemination of OrV is by releasing the infected adult beetles in the field. Healthy adult beetles are allowed to crawl on the viral inoculam, prepared by grinding the infected midgut in phosphate buffer @ 1g midgut/100 ml of buffer, for half an hour. The beetles are then kept under starvation for 12-24 hours. The beetles are released preferably at dusk in the infested coconut gardens at the rate of 12-15 beetles/ hectare.

The released field has to be monitored for pest incidence and data on pest damage is to be recorded once in six months. Following first release one more release may be required in some cases after 4-6 months. The percentage of petiole damage and spindle damage show significant reduction after 6-8 months of introduction of the virus. Reduced site occupancy of the pest in the breeding sites in the area of release and presence of OrV infected grubs in the breeding grounds are the other clear

indications of establishment of the viral pathogen. OrV can successfully be employed as a biocide to contain this important insect pest of coconut and oil palm in an eco-friendly manner and the control thus achieved is long lasting.

Treatment of breeding sites: Restricting and managing the breeding sites could check the proliferation of the pest. Incorporation of the weed plant, *Clerodendron infortunatum* Linn. (Verbenaceae) is very effective in

Clerodendron infortunatum

controlling the pest build up in the breeding sites. Larval-pupal or pupal-adult intermediates, adults with malformed wings *etc*. are some of the common abnormalities elicited by the plant in *O. rhinoceros*. These abnormal adults were unable to fly and survived for only 6-8 days against the longevity of 2-3 months for healthy adults.

Insect predators which feed on the eggs and early instar grubs of the beetle are frequently observed in the natural breeding grounds of the beetle. The important predators are *Santalus parallelus* Payk., *Pheropsophus occipitalis* Macleay, *P. lissoderus*, *Chelisoches morio* (Fab.) and species of *Scarites*, *Harpalus* and *Agrypnus*. As these predators help in the natural check of the pest population, conservation of the predator fauna is essential.

Trapping method: Trapping of adult beetles in a PVC trap using the pheromone 'Oryctalure' is a recent innovative method in the IPM for rhinoceros beetle. The traps are set up in the gardens and beetles trapped inside are collected periodically. These beetles are either killed or can be used for field release after inoculation with OrV.

Eriophyid mite *Aceria guerreronis* Keifer (Acarinae: Eriophyidae)

The nut infesting eriophyid mite *A. guerreronis* is one of the most serious pests of coconut causing significant reduction in yield.

Damage and symptoms:

The mite infests buttons during early stages of growth soon after pollination. Developing nuts harbour a large population of mites under the perianth. Symptoms appear approximately one month after

Early symptoms of mite damage

Mite damage symptom on mature bunch

initial colonization inside pollinated button. Appearance of white longitudinal patches just below the perianth and their development to triangular yellow patches are the early symptoms of pest infestation. As the nut grows these patches turn brown and longitudinal fissures and wartings appear on the nut surface. Drying and shedding of buttons and young nuts are also experienced.

Bioecology: The mites take about 7-10 days to complete their life cycle. The adult mite is microscopic, worm like, cream coloured, having 2 pairs of legs in the anterior end of the body. The female mite has high fecundity and lays about 100-150 eggs during its lifetime. The eggs are ovoid, translucent, glassy and having a measure of 35 microns in diameter. Various stages of the mites are seen in the floral bracts and the tender meristematic portion of the developing nuts. The adults move out of the perianth when population increases. Dispersal of the mite in nature takes place mainly through the wind. Honey bees, other insects, and birds visiting inflorescence of coconut also act as agents for dispersal. The mite is persistent throughout the year with maximum pest population during dry/ summer months from March to May. A period of high temperature with intermittent rains causing high humidity favours higher multiplication and rapid spread of the mite.

Microscopic view of mite colony with adults and eggs

Mite colony on the developing nut

Management:

Pesticide application: Effective and immediate management of mite is mostly achieved by the insecticidal spraying. A wide spectrum of pesticides including both systemic and contact insecticides have been evaluated and found effective for managing

the pest in the field. But, none of them are presently recommended due to their residual toxicity and the need for repeated application for getting satisfactory control. Even wettable sulphur recommended for mite management in the initial years was withdrawn due to its deleterious effects on the natural enemies of mite.

Botanical pesticides being ecofriendly are presently recommended for mite control. Spraying of neem oil garlic mixture (2%) or commercial botanical pesticides containing azadirachtin 10,000 ppm @ 0.004% or root feeding with neem formulations containing azadirachtin 50,000 ppm at 7.5 ml or azadirachtin10,000 ppm at 10 ml with equal volume of water is recommended for managing the pest. Depending upon the population buildup of the pest, pesticidal application has to be carried out during March–April after receipt of summer showers, post monsoon (October–November) and early summer months (December–January).

Preparation of spray solution:

To prepare one litre of 2% spray solution, 20 ml of neem oil, 20 g of cleaned garlic pearls and 5g of washing soap are required. Dissolve the soap in 500 ml luke warm water and add the neem oil into this soap solution and mix it well to obtain a good emulsion. Grind garlic pearls, mix it with 500 ml water and add this to neem oil -soap solution by sieving through a cloth to remove the debris of garlic pearls. The mixture is stirred well and can be used for spraying on the same day of preparation.

To prepare one litre of azadirachtin spray solution, take 4 ml of 10,000 ppm azadirachtin and mix it with one litre of water by stirring.

As the mite colonies are lodged on the soft tissues of the developing nuts covered by the perianth, pesticide should be applied as fine droplets on the perianth region from top so as to effect its penetration into the perianth lobes. Pesticide spraying should cover the 2 to 6 month old bunches since these bunches harbour maximum number of mites. Bunches, which are about to be harvested, need not be sprayed. If the pesticide is applied on the bunches using pneumatic hand sprayer 250 to 500ml spray fluid is required per palm. The neem based formulation can be applied through roots also for getting effective control of the pest.

Root feeding method: Trace an active semi hard, pencil thick and brownish coloured root without damage from about one meter away from the bole region. Make a slanting cut of 45° at the tip portion with a sharp knife. Take either 7.5 ml of azadirachtin 5% formulation or 10 ml azadirachtin 1% formulation and mix it with equal volume of water in a polythene pouch. Fully immerse the cut end of the root in the pesticide solution up to the bottom of the pouch and tie the mouth of the pouch containing the root with a twine. Keep the root safely in slanting position without causing any injury or spillage of the

Root feeding method

pesticide solution and cover the root gently with leaf mulch or loose soil.

Natural enemies: Natural enemies of coconut mite include mainly predatory mites and fungal pathogens. Mites belonging to phytoseiidae, are the major group of predators. *Neoseiulus baraki* is the predominant predatory mite. Other predatory mites include *Neoseiulus paspalivorus* and *Bdella* species. The insect predators encountered with coconut mite population in the field are thrips, coccinellids and syrphid maggots. But these are found only occasionally and in very few numbers. An increasing trend of incidence and better natural establishment of predatory mites in the field over the years are observed in most of the mite affected gardens. The activity of the predators is high during June to December in the field. Compared to the young developing nuts below three months, more predators are encountered in 4-6 months old nuts. The predatory mites are larger in size compared to the coconut mite and hence they gain entry only later into the nuts. This is one of the limiting factors for the wider use of the predators as effective biocontrol agents. However, conservation of the predatory fauna in the ecosystem is beneficial to regulate the coconut mite in nature.

The acaropathogenic fungus, *Hirsutella thompsonii* is the potential microbial agent of eriophyid mite throughout the world. Virulent native isolates of this fungus have been collected from various locations of India and formulation of a mycoacaricide based on this fungus is in progress.

Eriophyid mite infected with *Hirsutella thompsonii*

IPM for coconut mite: The IPM recommendation for management of mite consists of phytosanitary measures in coconut plantations including crown cleaning, burning of fallen mite infested

nuts and plant protection operation by spraying/root feeding of botanical pesticides thrice a year. In addition to this IPM package, adoption of integrated nutrient management package including application of NPK fertilizer as per recommended levels, recycling of biomass or raising of green manure crops in coconut basins, summer irrigation and moisture conservation by appropriate measures are also recommended for the management of the pest.

Red palm weevil *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae)

Damage and symptoms: Red palm weevil, the fatal enemy of coconut palm, is the most destructive pest in coconut plantation. This pest affects the palms particularly during the early periods of growth below 20 years. Adult beetles lay eggs in the soft tissues in the cut or injured portions and the emerging grubs tunnel into the stem and feeds on the tender tissues inside the palm. It remains hidden inside the palm for completing its life cycle and finally kills the palm if the infestation is unnoticed. The weevils are attracted to the rotting smell and the pest incidence is quite severe in areas where palms are infected with bud rot/ leaf rot or infested by rhinoceros beetle. Usually the red palm weevil infestation symptoms are ambiently visible at the advanced stage of pest infestation. However, on close monitoring of the palms some symptoms can be visible at the early stages also. Yellowing and later

Red palm weevil infestation symptoms on coconut- holes on stem

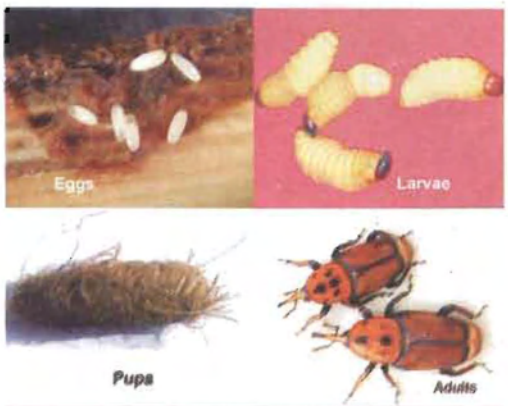
Oozing of liquid from trunk

wilting of the inner and middle whorl of leaves, small circular holes on the palm trunk with oozing out of a brown viscous fluid, longitudinal splitting of leaf base and presence of cocoon/chewed up fibers at the base of affected palm are the major symptoms of red weevil infestation. Gnawing sound of grubs is audible when closely mointored with ears on the infested trunk of palm.

Entry of the pest through the crown is the most common and most fatal type of infestation. The grubs in such cases stay very close to the cabbage portion (growing point) of the palm and results in drying of the young heart leaves. In seedlings and younger palms entry of the pest through the bole region is generally noticed. Shallow planting and injuries to the soft stem due to mechanized cultivation practices are major reasons for this type of pest entry.

Crown toppled palm

Bioecology: The adult weevils measure 35 mm long and 12 mm wide and are ferruginous brown in colour. The snout is elongated in both sexes and the dorsal apical



Life stages of red palm weevil

half of the rostrum in males is covered with a patch of short tuft of brown hairs. The snout of female is bare, relatively slender and a little longer than the males. The mean fecundity is about 175 eggs per female. The creamy white oval eggs are laid in small holes scooped out on soft tissues of the palm. After hatching, the grubs tunnel their way into the trunk and feed on the internal contents. The full-grown grub is stout, fleshy and apodous measuring 50mm long and 20mm in width. The fully grown grubs make elongate oval fibrous cocoon around them by winding the fibrous threads from food material. Pupal stage lasts for 12-20 days. The life span of the adult is 76-133 days. The weevil completes its egg to adult stages in 4 months.

Management: Prevention of pest entry into the palm is the major step to be adopted

in the IPM package. Fermenting smell emanating from the injured portions of the palm attract the weevils for egg laying. This can be prevented by avoiding injuries on the palm and by treating the wounds, if any, with coal tar + carbaryl. Prophylactic leaf axil treatment for *O. rhinoceros* keeps away red weevil also. Whenever leaves are cut, a petiole length of 1.2 m should be retained on the palm to prevent the entry of the pest through the cut petiole. Timely fungicidal treatment for bud rot and leaf rot also is essential. Early detection of pest attack is the most important factor for successful management of red palm weevil. Curative

Red palm weevil pheromone synthesized at CPCRI

treatment with 1% carbaryl is effective in the management of the pest. After plugging all the holes on the lower part of the palm the insecticide solution is administered into the palm with a funnel through the uppermost hole. If the entry of the pest is through the spindle, cutting the highly rotten part and pouring the insecticide through the crown is effective. Root feeding of the affected palm with monocrotophos @10ml+10ml water is effective in controlling the pest stages inside the palm. Due to the residue problem of this systemic insecticide, a waiting period of 45 days is to be strictly adopted when this insecticide is used for root feeding in yielding palms. To save non-bearing palms this method can be adopted. Trapping the floating population of weevils with log traps treated with fermented toddy is also recommended. Fresh coconut logs (50 cm long and split longitudinally), cut surfaces of which are treated with fermenting toddy are placed one above the other to serve as an effective trap for red weevil. Trapping of red palm weevil using aggregation pheromone (Ferrugineol) lures in food-baited bucket traps forms an important component of the IPM strategy. Traps are set @ 1 trap/ha and hanged on coconut trunk at a height of 2 m from ground. Usually, the traps are serviced once a week and the food bait is replaced. When the trap is set the chemical from the sachet gets released (volatilized) into the surroundings, thus attract the weevil towards the trap and the food attractant in the bucket orients the attracted weevil into the trap. Once trapped, the insect on contact with the insecticide mixed with the food bait gets killed.

Maintenance of field sanitation by removal, splitting and burning of dead palms, which harbour various stages of the pest, helps a lot in reducing fresh incidence and hence should be considered as an important step in IPM.

Leaf eating caterpillar: *Opisina arenosella* Walker (Lepidoptera: Oecophoridae)

Damage and symptoms: *O. arenosella* is one of the dominant caterpillar pests of

coconut palm. This pest periodically assumes severe proportions in coastal and backwater areas and in the vicinity of water bodies in the interior parts of peninsular India. The larvae of this insect feeds on the under surface of leaflets resulting in considerable reduction on the photosynthetic area of the palm. Severe

***O. arenosella* infested coconut plantation**

infestation by this pest reduces the yield of the palm and in addition renders the leaves unsuitable for thatching and other purposes. Apart from coconut *O. arenosella* affects palms like palmyrah, talipot palm, wild date and ornamental palms. The caterpillars of *O. arenosella* construct galleries of silken webs reinforced with excreta and scrapes

***O. arenosella* infestation symptom on coconut leaf**

of leaf bits. Diagnostic symptoms of infestation are the presence of galleries on the lower surface with live or dead stages of the pest and the upper epidermis intact. Damage results in drying of the outer and middle whorl of leaves.

Bioecology: The pest infests the coconut palm throughout the year from mild to medium intensities. Life cycle of this pest is completed in 8-10 weeks. The fully-grown larva is about 15mm long, light green with reddish brown stripes and with a black head. It pupates in a silken cocoon in the larval gallery.

The adult is a greyish moth measuring 10-15 mm long with a wingspread of 20-25 mm. Climatic factors particularly relative humidity favours the pest build up.

Life stages of *Opisina arenosella*

Management: The pest can be well managed by biological control methods. However, an integrated pest management strategy is to be adopted in an epidemic out break.

Mechanical: Cutting and burning the heavily infested and fully dried outermost 2-3 leaves removes the pupae and other pest stages in case of severe infestation.

Biological control: *O. arenosella* is subject to attack by a variety of indigenous parasitoids and predators. Biological control by the release of stage specific parasitoids is the major component of IPM. Techniques have been developed for mass production of the promising parasitoids. The pest infested areas should be monitored regularly and parasitoid releases should be initiated at the post monsoon period during November–December if there is any pest incidence. Parasitoids are to be released at the fixed dosages depending on the target stages of the pest at fortnightly intervals till the pest population is suppressed.

The larval parasitoid *Goniozus nephantidis* (Bethylidae) is released if the pest is at 3rd larval stage or above @ 20 parasitoid /palm and *Bracon brevicornis* (Braconidae) @ 30 parasitoid/palm. The pre-pupal parasitoid *Elasmus nephantidis* Rohw. (Elasmidae) and the pupal parasitoid *Brachymeria nosatoi* Habu.(Chalcididae) are also very effective in managing the pest. They are released @ 49 and 32%, respectively for every 100 pre- pupae, pupae estimated to be present on the palm. Before field releasing, the parasitoids should be fed with honey and newly emerged parasitoid can be released after three days of emergence.

Goniozus nephantidis *Bracon brevicornis*

Elasmus nephantidis *Brachymeria nosatoi*

Feeding the parasitoids with honey and exposing the newly emerged parasitoid to the host odours (Smell of the volatiles of the injured *O. arenosella* larvae and gallery volatiles) is found to improve the host searching efficiency of *G. nephantidis.*

Insect and spider predators are abundant in the coconut ecosystem. The dominant insect predators are the carabid beetles *Parena nigrolineata* Chaud., *Calleida splendidula* (F.), anthocorid *Cardiastethus* spp. and chrysopid *Ankylopteryx octopunctata candida* Fab. Species of *Cheiracanthium, Rhene* and *Sparassus* are the important spider predators. These predators exert significant degree of biological suppression of the pest.

Chemical treatment: During severe sporadic out breaks, the pest can be checked to a lower level by spraying with less toxic insecticides like diclorvos 0.02% or malathion / phosalone each at 0.05% if the pest is in an active larval stage. The

insecticidal spraying has to be followed with subsequent release of parasitoids after 21 days at fixed norms and intervals. In areas of periodical out breaks monitoring on the build up of the pest population and adoption of appropriate management methods are essential steps. Proper irrigation and adequate fertilizer application should be done to rejuvenate the pest-affected palms.

White grub: *Leucopholis coneophora* Burm. (Coleoptera: Melolonthidae)

Damage and symptoms: The grubs of *L. coneophora* feed on the roots of coconut palm. They occur in sandy loam soils and feed on tubers, rhizomes and roots of vegetables, which are grown as intercrops in coconut gardens. Continuous feeding by the grubs on mature palms results in yellowing of leaves, premature nut fall, tapering of crown, delayed flowering, retardation of growth and reduction in yield.

Coconut white grub- *Leucopholis coneophora*

Bioecology: The grubs are creamy white in colour with a brown head. Adult beetles are of chestnut brown colour. Eggs are laid in soil and the hatched out grubs feed on the root of coconut and intercrops. The pest has an annual life cycle with peak grub population in the field during September to October. Emergence of the adult beetles from the soil occurs during May-June following onset of pre monsoon showers.

Management: Deep ploughing during pre and post monsoon periods exposes the grubs to predators. Setting up of light traps in the infested field helps to collect and destroy the beetles during peak period of emergence. Insecticidal recommendation for white grub management is either by application of phorate 10G in the palm basin @ 100g/palm and incorporating it in the soil to a depth of 30cm by raking or drenching the root zone with chlorpyriphos 20EC @ 0.05% (14 litres/palm) during May–June and September–October.

Coreid bug: *Paradasynus rostratus* Dist. (Hemiptera: Coreidae)

Damage and symptoms: Adults and nymphs of *P. rostratus* feed on the buttons and young nuts causing nut fall and malformation of mature nuts. The bugs pierce their stylets through the perianth and suck sap from the tender meristematic region of the coconut buttons.

Coreid bug-adult

Coreid bug nymphs

Feeding point appears as brownish necrotic lesions and the affected nuts fall off. Damaged nuts retained in the bunches develop furrows and cracks on nut surface. The nuts also show crinkling, gummosis and become barren. The pest has also been reported in guava, cashew, tamarind and cocoa.

Coreid bug damaged coconut button

Coreid bug damage on mature nuts

Bioecology: The eggs are laid on leaf petiole, spathe, spadix or young buttons and they hatch in 8-10 days, nymphal development takes 30 days with 5 instars and adult lives for 50 days.

Management: Control of coreid bug is achieved by insecticidal spraying with 0.1% carbaryl or placement of phorate 10G @ 5g/ palm in two polythene sachet in the stalk region of youngest two bunches close to the leaf axils.

The red ant, *Oecophylla smaragdina* has been found to have antagonistic effect on the pest.

MINOR PESTS

Mealy bugs: *Palmiculter palmarum* Ehrhon, *Pseudococcus cocotis* Maskell and *P. longispinus* Targ. (Hemiptera : Pseudococcidae)

The mealy bugs colonize on all tender parts like spear leaf, spadix, inflorescence and inside the perianth of nuts. Mealy bug infestation on spathe affects development of young buttons and results in poor nut set. Drying up of spadix is also reported. Colonization by mealy bug on spindle leaves results in failure of heart leaf development and results in death of seedling. Mealy bug infestation is indicated by the presence of waxy white powdery coating on affected parts. Ants which are found in association with the mealy bug colonies help in the dispersal of this pest. Management of this pest is achieved by spraying chemical pesticides like monocrotophos (0.05%) or dimethoate (0.05%). The coccinellids and lycaenides are the natural enemies reported on various mealy bugs on coconut.

Mealy bug infestation on spadix

Mealy bug infestation on leaf

Scale insects: *Aspidiotus destructor* Signoret, *Aonidiella orientalis*. (Newstead) and *Lepidosaphes mcgregori* Banks (Hemiptera: Diaspididae)

Scale insects are usually found in colonies of dense masses on the lower surfaces of leaves, except in extremely heavy infestations where it may be present on both sides. It may also be found on petioles, peduncles and nuts. Mature scales are found on the older leaves. Infestation

***Aspidiotus destructor* infested coconut leaf**

is typically associated with yellowing in areas of leaves where the scales are present. The yellowing is caused by the removal of sap by the sucking mouth parts and the toxic effects of the saliva that kills the surrounding tissues at the feeding site. The pest incidence is at its peak during summer months. In case of severe infestation, spraying with 0.1% fenthion / 0.05% dimethoate / 0.05% monocrotophos were found effective for management of the pest. The predatory coccinellid beetle, *Chilocorus nigritus* Fab. exerts good natural control of the pest in the field.

Slug caterpillars : (Lepidoptera: Limacodidae)

The slug caterpillars are sporadic pests on coconut. Their infestation becomes very severe in post monsoon and summer months. The

Latoia lepida ***Contheyla rotunda***

caterpillar voraciously feeds on the lamina, leaving only the midrib. These are polyphagous insects and hence the management becomes a problem at times. *Contheyla rotunda* Harm., *Latoia lepida* Cram. and *Macroplectra nararia* M. are slug caterpillars reported from coconut in India. For the management of the pest during the out break season chemical control using carbaryl 0.1%, is recommended. Cutting and burning

Macroplectra nararia

of severely affected leaves along with various stages of the pest in the epidemic outbreak is practiced to avoid further population build up.

Stem and bark weevil: *Diocalandra stigmaticollis* Gyll. (Coleoptera: Curculionidae)

The adult is a brown weevil of about 6mm size and it infests the cuts and wounds on the

palm trunk and petiole. It is more common on palms with stem bleeding disease. The larvae burrow into the soft tissues of the bark. In infested palms, the production of leaf and spathe is delayed. Tunneling by the weevils within the leaf petiole that is close to the trunk results in loosening of fibers and the petiole loses its grip and hangs from the trunk. Swabbing the trunk with 0.05% quinalphos after removing the hanging petioles gives effective control of the infestation.

Caterpillars affecting nuts and floral parts:

A few species of caterpillars *viz.*, *Cyclodes omma* Van der Hoeven (Noctuidae), *Batachedra arenosella* Wlk. (Tineidae) and *Syntomis* (*Amata*) *passalis* Fab. (Arctiidae) are found to infest buttons and other floral parts of coconut palms. However, the natural enemies of the coconut ecosystems keep them under check. In cases of severe infestation application of 0.1% carbaryl is recommended.

Nut borer -*Cyclodes omma*

Leaf roller: *Gangara thyrsis* Moore (Lepidoptera: Hesperiidae)

The caterpillar of this butterfly constructs a tube by cutting and rolling a part of the leaflet and feeds on the leaf blades leaving only the ribs. It becomes full grown in about five weeks. The full grown caterpillar is pale green with reddish marking and body is concealed in a covering of white waxy filaments. It pupates within the leaf roll lasting for 10 days. The pupa vibrates vigorously when disturbed producing a rattling sound. The infestation is more on young seedlings. The adult butterfly is brown with six yellow spots on forewings. Collection and destruction of caterpillars give good control of the pest.

Shot hole borer: *Xyleborus perforans* (Wollaston) (Coleoptera: Scolytidae)

The beetles make numerous minute holes on the bark. Stem injection of 0.2% diclorvos / swabbing the bark with 0.1% chlorpyriphos is effective in managing the pest.

Termites: *Odontotermes obesus* Ramb. (Isoptera : Termitidae)

Termites cause serious damage to nursery seedlings and adult palms. They feed on the collar region of the seedlings and result in wilting of the central shoot. In adult palms termite attack is observed on the bark. Drenching the nursery with 0.05% chlorpyriphos twice at 20-25 days interval manages the pest in the nursery. In older palms the affected trunk may be swabbed with the chemical. Adequate irrigation in

nursery beds is recommended to avoid termite infestation on young seedlings.

Foliage mites:

Red mite, *Raoiella indica* Hirst, the spider mite, *Oligonychus iseilemae* Hirst and *Tetranychus ludeni* Zacher are the important species occurring on coconut foliage. The mites inhabit the lower surface of leaves, suck sap and cause drying of the affected leaves. Seedlings are more prone to mite infestation. The orange mite, *Dolichotetranychus vandergooti* Oudemans infests the perianth of nuts. Severe infestation of mites either alone or in combination with fungal infection may cause nut fall. Spraying acaricides like 0.05% dicofol or dimethoate or 0.2% wettable sulphur controls the pest. Predators like *Amblyseius* spp. help in checking the population of the pest in nature. During the peak period of mite infestation (summer months) provision of adequate shade and irrigation will help in reducing the mite incidence in seedlings.

Rodents :

Among the vertebrate pests rodents are the major threat to coconut all over the world. In India, 10 species of rodents are known to coexist in coconut and its intercrops. Rodents are the major pests of coconut in Lakshadweep Islands where around 40% nuts are lost due to rat damage. The arboreal black rat *Rattus rattus wroughtoni* Hinton is nocturnal and live mainly on the crown of the palm. They breed throughout the year with peaks during February-March and July-August. They make small holes (about 5cm diameter) near the perianth region of tender nuts and feed on the inner contents. The damaged nuts fall from the attacked bunch. Nuts of 3 to 6 month maturity are mostly preferred. Unopened spathe, female flowers and leaf stalks are also attacked. The burrowing rodents namely *Bandicota bengalensis* Gray (Lesser bandicoot), *B. indica* Bech. (Larger bandicoot) and the

Rat damage symptom on coconut

gerbil *Tatera indica* Hardwicke make extensive burrows in soil and damage the coconut seedlings by eating away the cabbage portion.

Management: An integrated approach consisting of mechanical barriers, farm sanitation, trapping and chemical methods are generally followed for rodent management.

Mechanical barrier: In older coconut plantation, banding the coconut trunk with G.I. sheet 25 to 30 cm wide, at a height of 2 m above ground level is effective in controlling arboreal rats where leaves of palms in different rows do not touch each other.

Orchard sanitation: Proper and timely removal of weeds from the coconut plantation exposes the burrows and minimizes the

damage by burrowing rodents. Removal of dried leaves, spathes and matrix regularly from the crown exposes the nesting places of arboreal rats to predators.

Trapping: Trapping using live or death traps is the safest but labour intensive method for controlling rodents. Different types of rodent traps like bamboo trap, wooden box trap, PVC tube trap *etc.* are used by farmers.

Poison baiting: The use of single dose anticoagulant rodenticide, bromodiolone (0.005%) is effective in the management of black rat, *R. r. wroughtoni*. Placement of 10g bromodiolone wax blocks two times at an interval of 12 days on the palm crown of one tree out of every 5 trees is recommended for effective control of black rat. If the damage is restricted to certain palms, only such palms require baiting

Poison baiting using zinc phosphide effectively controls the bandicoots and gerbils. Poison baits can be prepared by mixing 95 parts of raw rice, 3 parts of coconut oil and 2 parts of zinc phosphide. Tubers of cassava, coconut kernel pieces and dried fish can also be used as baits. Since zinc phosphide is an acute poison, rodents quickly develop bait shyness towards this poison bait. In order to overcome the problem of bait shyness plain baits (without poison) should be kept in each active burrow for 2 to 3 days before putting poison bait.

Group approach in IPM

For control of any pest on coconut, tangible results can be obtained if farmers adopt the IPM strategies on a community basis rather than following in individual holdings. The contiguous and homestead nature of coconut gardens and the flight range of pests warrant the necessity for adoption on a group approach mode. In the various operations like spraying, release of biocontrol agents, plantation sanitation *etc.* it will be highly ideal to take up the programmes on a massive manner as it will reduce the cost of operations and yield sustainable results.

Future thrust

Effective IPM strategies have been developed against major pests of coconut. But these strategies are to be refined further for making them more cost effective, ecologically safe and farmer friendly. Emphasis should be given for popularization of bio-intensive IPM technologies among farming community. Besides, more research programmes need be undertaken for assessing the possible pesticide residues in the crop and environment. More concentrated studies are required in the following areas like use of pheromones and kairomones in coconut pest management, various abiotic and biotic factors responsible for outbreak of pests like slug caterpillars, scale insects *etc.*, factors responsible for changes in the pest scenario and effective control strategies against emerging pests like coreid bug and other sucking pest complex. Current efforts of the Institute are mainly oriented in this direction.