

# Adoption of Integrated Pest Management Strategies for Sustainable Production in Coconut

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The annual yield loss due to pest incidence in Kerala alone was estimated to be 618.5 million nuts. If timely control measures are not taken up, the pest attack may lead to substantial economic damage or may prove fatal to the palm.

Hence for maintaining sustainable coconut production, adoption of Integrated Pest Management strategies emerges as one of the most important priority areas.

Coconut (*Cocos nucifera* Linn) is the most important versatile tree crop cultivated in the tropics providing livelihood and employment securities to the rural agrarian mass in the region. More than 10 million people in India are dependent on coconut in various ways. The crop contributes more than Rs.8900 crores to the country's GDP apart from an export earning of Rs.695 crores (Mathew, 2010). Coconut is essentially a crop of marginal and small farmers in India, particularly in Kerala state, which holds 43 percent of the area and contributes 38 percent of production of the crop in India. The low size of the land holding by coconut growers is a serious challenge to both profitability and sustainability of the crop. An integrated farming system

which utilizes the major crop, companion crops, and also the animal husbandry component in the system, plays a pivotal role in the sustainable resource crediting of the ecosystem.

Adoption of modern agro-techniques such as improved planting material, integrated nutrient management practices and integrated plant protection measures is essential in integrated farming system. It is therefore obligatory to practice these crucial associated components by a coconut farmer so as to obtain a lucrative income from his farm. Coconut palm with its perennial nature provides a continuous supply of food and shelter for the pest population build up which causes substantial crop loss. More than 800 species of pests

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have been reported from coconut in India (Kurian *et al.*, 1979). The annual yield loss due to pest incidence in Kerala alone was estimated to be 618.5 million nuts (Abraham, 1994). If timely control measures are not taken up, the pest attack may lead to substantial economic damage or may prove fatal to the palm. Hence for maintaining sustainable coconut production, adoption of Integrated Pest Management strategies emerges as one of the most important priority areas.

### Coconut pest scenario in India

Changes in the cropping systems in coconut gardens, large scale adoption of advanced agro-techniques for higher productivity, the changing abiotic environment of the coconut gardens and also the neglected condition of the farm leading to malnutrition of palms have led to the emergence of many new pest problems in coconut. Based on the frequency of distribution and severity of damage inflicted on the crop, the pests are grouped under three categories viz., the major pests, minor pests and sporadic pests.

### Major pests

The major pests of coconut palm in India are the rhinoceros beetle (*Oryctes rhinoceros* Linn.), red palm weevil (*Rhynchophorus ferrugineus* Oliv.), the black headed caterpillar (*Opisina arenosella* Wlk.), coconut mite (*Aceria guerreronis* Keifer) and the root grub (*Leucopholis coneophora* Burm.).

The rhinoceros beetle has a wider distribution in all coconut growing tracts in India. Damage is caused by



Leaf damage by rhinoceros beetle



Spathe damage by rhinoceros beetle

the adult beetles that bore into the unopened spindle and inflorescence. The beetle breeds in the decaying organic debris. Red palm weevil is the killer pest of coconut palm, especially on young palms. The grubs are the destructive stage of the pest. All life stages of the pest can be seen in the infested palms. The grubs tunnel through the crown, trunk or bole region of the palm feeding on the soft tissues. Severe infestation leads to death of the palm, if timely control measures are not taken up. The larval stages of black headed caterpillar invade palms of all ages and palms near the vicinity of water bodies are more prone to the infestation. Living within the silken galleries on the

lower surface of leaflets, the caterpillars feed on the chlorophyll containing leaf tissues. The root grubs attack palms of all age groups grown in sandy loam soils. The grubs feed on growing roots resulting in poor growth. Coconut mite has emerged in the pest scenario in India during 1998 and it has occupied the status of a major pest within a short time. The pest affects the buttons during the early stages of growth causing nut fall, reduction in size and malformation on the nut surface.

### Minor pests

These are species of insects affecting coconut palm either during certain seasons, or may be present in the ecosystem always but may not be causing severe economic loss. But under favourable conditions some minor pests assume the status of potential pests. Examples are the members of the sucking group of pests comprising scale insects, mealybugs, coreid bug (*Paradasynus rostratus* Dist.) and the foliage mites. Most of these pests are suppressed in nature either by the natural enemy complex associated with them in the field or due to changing abiotic factors, particularly rainfall.

### Sporadic pests

A few species of lepidopterans such as *Contheyla rotunda* Hamp., *Macroleptera nararia* Moore and *Parasa (Latoia) lepida* Cram. commonly known as slug caterpillars and another defoliating caterpillar *Turnaca acuta* M. are found to damage coconut palms in contiguous areas on a massive scale. These sporadic pests appear all of a



sudden particularly during hot weather conditions and cause extensive defoliation leaving in many cases only the mid rib of leaflets. The infestation is first noticed on older petioles and the numerous caterpillars migrate to the inner whorls of leaves. On receipt of few showers at the peak infestation period, the pest population gets drastically reduced and the natural pest suppression is achieved by the combined action of the natural enemies and abiotic factors.

**Symptoms of pest attack**

A thorough knowledge on the symptoms of infestation by various pests is very vital in properly



*Leaf eating caterpillar infested coconut garden*



*Leaf eating caterpillar on coconut leaf*



*Crown toppled palm by red palm weevil infestation*



*Leaf axil damage by red palm weevil*

identifying the pest incidence and also to initiate timely pest management schedule to combat the situation. This is more relevant in case of the killer pest like red palm weevil and potential pests like black headed caterpillar that affect palms in extensive areas on a massive devastating scale.

Symptoms of infestation by the major pests and potential minor pests are described below. The rhinoceros beetle attacks the developing spindle leaf, petioles or inflorescence. As the adult beetle bores deep into the affected part, it pushes out the chewed up tissue as frass mostly seen extruding from the pest entry point. When the injured spindle leaf opens up the lamina presents a characteristic geometric “V” shaped cut pattern. The damage

on petiole results in holes and when spathe is affected it ends up with the drying of inflorescence.

Though red palm weevil infestation symptoms are usually visible at a later stage of pest infestation, a close monitoring by the farmer shall be ideal to spot out the infestation at an early stage. Yellowing and wilting of the inner and middle whorls of leaves, small circular holes on the trunk or crown with oozing out of a brown viscous fluid, longitudinal splitting or cracking on the petiolar base, presence of cocoons or chewed up fibres on the base of the affected palm are symptoms that aid in early identification of pest attack. Toppling of crown of affected palm



*Initial symptoms of mite damage*



*Coconut bunch with severe mite damage*



*Coreid bug damage on coconut button*



*Malformed and puny nuts due to coreid bug damage*

is the final symptom of pest infestation.

Presence of larval galleries on the lower side of leaflets with live or dead stage of the pest is the most diagnostic symptom of black headed caterpillar attack. The affected tissue gets dried up and forms conspicuous grey patches on the upper surface of leaf. The infestation starts usually from the outer leaves to inner ones.

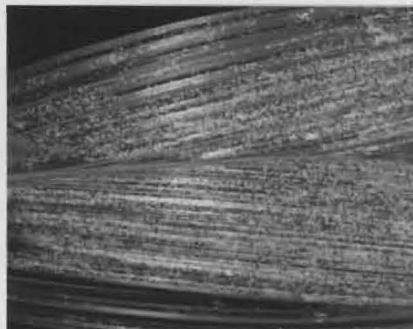
Colonies of coconut mite suck up the sap from the tender meristematic region of buttons covered by the perianth. The first symptom of mite attack is the appearance of elongated white lines on young developing nuts below the perianth. Very soon these feeding marks appear as pale yellow triangular patches and they gradually turn brown. As the nut grows, wartings and longitudinal

fissures appear on the nut surface. Severe infestation leads to poor development of nuts with malformation and reduced kernel content.

Symptoms of root grub infestation are yellowing of leaves, premature nut fall, tapering of crown, delayed flowering, retarded growth and reduced yield. The feeding points by coreid bug appears as brownish necrotic lesions. The affected nuts fall in most cases. The partially affected nuts show malformation with cracks and furrows on the nut surface and gummosis. Barren nut production is also experienced in severe cases of pest attack. Severe infestation by the scale insects and mealybugs results in foliar yellowing, nut fall and poor setting percentage. Presence of attendant ants on the crown of palms is an indication of infestation by scale insects or mealybugs.



*White grubs in coconut basin*



*Scale insects on coconut leaf*

### Recommended IPM packages

Effective IPM packages have been formulated to combat various pests of coconut (Nair *et al.*, 1997 and Rajan *et al.*, 2009a). Depending upon the situations adoption of an IPM package or a suitable component of the IPM package has to be practiced by the farmer to manage the pest attack.

The major components of IPM for rhinoceros beetle consists of sanitation, mechanical, chemical and biological control methods. Sanitation method involves disposal of dead and decaying organic debris in the coconut gardens to avoid the breeding grounds of adult beetles. By periodic observation on the crown of palms during the peak season of pest occurrence (June-August) the presence of the pest can be identified. In such cases the beetles can be extracted with a metallic hook. Filling of powdered neem cake or marotti cake at 250g per palm mixed with equal volume of river sand into the top most three leaf axils around spindle leaf during May, September and December is a prophylactic method to prevent infestation by rhinoceros beetle as well as red palm weevil. Placement of naphthalene balls @ 12g per palm and covering them with sand also is highly effective to ward off the pest attack.

Biological suppression using two microbial agents viz., the green muscardine fungus *Metarhizium anisopliae* M. and the viral pathogen *Oryctes rhinoceros* virus is a highly effective management method for suppressing the pest. Treatment of breeding grounds of the beetle using



the fungal spores of *M. anisopliae* at  $5 \times 10^{11}$  spores per  $m^3$  is effective to manage the pest in the breeding ground itself. Release of baculovirus infected beetles @ 12-15 beetles per hectare is found effective in the bio-suppression of the pest. Use of pheromone trap employing the synthetic pheromone in a PVC tube trap can be practiced either to reduce the pest population or the trapped adults can be used for inoculation with the viral pathogen and subsequent field release. Incorporation of the weed plant *Clerodendron infortunatum* Linn in the breeding ground is recommended to suppress the pest population (Chandrika Mohan and Nair, 2000).

The IPM for management of red palm weevil consists of maintenance of field sanitation, curative method using insecticide and trapping of field population of the pest employing pheromone trap. Prevention of the pest entry into the palm is the major step in the management (Abraham and Kurian, 1972). This can be accomplished by avoiding injuries on the palm and by treating wounds, if any, with coaltar-carbaryl mixture. When leaves are cut, a petiole length of 120 cm is to be retained on the palm to prevent pest entry into the trunk. Removal of palms beyond recovery stage and burning of the affected trunk or crown portion to kill various stages of the pest in the affected palm are highly essential as a sanitational method in the management of red palm weevil. Early detection of pest attack and curative treatment using one percent carbaryl is

recommended as a chemical treatment. Trapping and destruction of adult weevils employing pheromone trap is another method of reducing pest population. When pheromone trapping is practiced, the farmer has to strictly follow up the precautions stipulated in employing the pheromone trap. It is more important to keep in mind that to achieve a tangible result on management of red palm weevil, an effective combination of all recommended practices with focus on sanitational and preventive measures is to be practiced.

A bio-intensive IPM strategy supplemented with mechanical and chemical method is recommended to effectively manage the black headed caterpillar. Mechanical method of cutting and removing the affected leaflets or petioles is recommended in mild cases of pest incidence. In case of severe epidemic outbreaks removal and burning of fully dried 2-3 outer whorls of leaves are to be adopted. In an epidemic outbreak spraying with 0.02 percent dichlorvos or 0.05 percent malathion is recommended to regulate the high pest population. The spraying has to be followed by release of natural enemies after 20 days. A rich natural enemy fauna comprising larval, pre-pupal and pupal parasitoids is associated with the natural regulation of the pest in the field (Pillai and Nair, 1993). These effective natural enemies are reared in the laboratories and released in the field to augment the natural enemy population to achieve effective management of the pest. To combat the pest population the

recommended parasitoids like *Goniozus nephantidis* (Bethyridae) and *Bracon brevicornis* (Braconidae) are to be released at the rate 20/30 parasitoids respectively per palm. The pre-pupal parasitoid *Elasmus nephantidis* (Elasmidae) and the pupal parasitoid *Brachymeria nosatoi* (Chalcididae) are recommended @ 49 and 32 per cent for every target stage of the pest.

For management of coconut mite an integrated strategy combining plant protection and nutrient management is recommended. The plant protection schedule involves spraying / root feeding of neem based pesticides three times a year during April-May, September-October and December-January to regulate the pest population build up. Azadirachtin 10000ppm at 0.004 percent spray or root feeding of 50,000ppm azadirachtin at 7.5ml or 10,000ppm azadirachtin at 10ml mixed with equal volume of water are recommended for regulation of the pest. For nutritional management, balanced application of NPK fertilizers, raising of suitable green manure crops in the coconut basin and its incorporation into soil, organic recycling of farm biomass and soil moisture conservation are recommended.

Deep ploughing during pre and post monsoon period and setting up of light traps are effective in management of root grubs. In severe case of root grub incidence, drenching with chlorpyrifos 20EC at 0.05 percent (14litres per palm) during May-June and September-October is recommended.



**Importance of pest monitoring**

For the successful implementation of an IPM programme, the farmer has to effectively monitor the pest incidence in the field. This is particularly true in a crop like coconut that has a perennial nature and occupies extensive areas in contiguous manner. For an effective monitoring of the pests, knowledge on the seasonal occurrence and the pest infestation symptoms is essential. Regular surveillance by the farmer helps in an effective monitoring system to adopt appropriate management schedule. It helps to organize the plant protection operation at the correct stage of pest incidence and this will avoid economic crop loss by the farmer. A calendar given below indicating probable pest incidence shall help the farmers to know about the seasonal occurrence of various pests and to implement appropriate IPM strategies.

**Need for group approach and capacity build up**

Proper utilization of available resources is highly essential to enhance productivity of coconut. The predominance of small holdings and also the peculiar situation of homestead nature of cropping system particularly in Kerala, the major coconut producing state, call for a change in the operational management of coconut farms. Many pilot scale surveys have indicated the low level of technology adoption and also the lack of proper knowledge on various technologies, including plant protection among farmers. Thus,

Month	Probable peak incidence of various pests
January-February	Red palm weevil, black headed caterpillar, coconut mite
March-May	Coconut mite, black headed caterpillar, sucking pests like scales, mealy bugs, slug caterpillars, whiteflies
June-August	Rhinoceros beetle, coreid bug, red palm weevil, root grubs
September-October	Red palm weevil, rhinoceros beetle, coreid bug, coconut mite, root grubs
November-December	Red palm weevil, coreid bug, black headed caterpillar, coconut mite

there is an urgent need for modified extension strategies to create confidence among farming communities for technology adoption. The front line demonstrations and on farm trials by various scientific institutions, particularly those studies carried out by Central Plantation Crops Research Institute with funding from agencies like Coconut Development Board, Department of Biotechnology, NATP under Indian Council of Agricultural Research, Asian and Pacific Coconut Community etc. have indicated a wide gap between the yield realized under proper technology adoption programmes and the yield achieved by farmers practices. These field programmes have indicated the impact of community based approach. Cluster approach by consolidation of fragmented coconut farms have yielded fruitful results on technology adoption. Based on these experiences the Coconut Development Board has already initiated scaling up the

cluster approach in larger areas comprising 25-50 ha. coconut gardens in a few districts in Kerala. Along with this type of programmes it is worthwhile to combine capacity building up programme on various technologies by innovative methods like Farmer-Field Schools (FFS), by which the technology acquisition level of the farming group can be enhanced substantially.

In the case of IPM adoption in coconut, the impact shall be great as the results achieved through introduction / augmentation of potential biocontrol agents, field sanitation and organic recycling of farm biomass etc. have long range beneficial effects in the field. Massive technology adoption programmes would benefit a perennial crop like coconut.

**Success stories on IPM technology adoption in coconut**

IPM packages formulated by CPCRI have been widely field demonstrated and validated during the past two decades. The



biointensive IPM package for rhinoceros beetle utilizing the green muscardine fungus and *Oryctes rhinoceros* virus (OrV) had shown significant results in the field in many parts of India, viz., Minicoy island (Lakshadweep), Andaman islands, South Kerala (Kayamkulam), North Kerala (Kasaragod) and Coastal Andhra Pradesh (Ambajipet). Mohan *et al.* (1989) reported the feasibility of biological suppression of rhinoceros beetle within two years of the first release of OrV in Minicoy. The impact of re-release of OrV in the mainland of India was demonstrated in Trissur district (Biju *et al.*, 1995). A massive technology implementation on IPM of rhinoceros beetle carried out in 2000 ha coconut gardens in Alappuzha and Kasaragod districts resulted in 75.0 percent reduction in leaf damage, 96.0 percent reduction in spindle damage and 62.5 percent reduction in spathe damage within three years (Nair *et al.*, 2010). The IPM technology adoption programme in East Godavari district of Andhra Pradesh also showed 56.5 and 62.8 percent reduction in leaf and spindle damage respectively by the pest (NATP, 2003).

Sathiamma *et al.* (1996) reported 94 per cent reduction in black headed caterpillar incidence during the third year of technology implementation. A large scale technology implementation for management of black headed caterpillar carried out at South Kerala, North Kerala and Coastal Karanataka by CPCRI during 1999-2002 covering 1400 ha. resulted in

more than 93 percent reduction in infestation and by the end of third year the pest attack was totally absent (Chandrika Mohan *et al.*, 2010).

Field demonstration on management of red palm weevil has shown significant reduction in infestation. Within a period of 28 months the infestation percentage could be brought down to 0.86 percent from an initial level of 5.55 percent (NATP, 2003). In the case of coconut mite Rajagopal *et al.* (2003) reported the success of IPM implementation indicating reduction of pest incidence from 68.0 percent to 15.3 percent.

#### Emerging and quarantine pests

The constantly changing climatic factors particularly due to the rise in temperature by global warming warrants surveillance and pest monitoring for tracking the occurrence of new pests or sporadic occurrence of potential sucking pests like whiteflies. Two types of whiteflies, viz., areca whitefly, *Aleurocanthus arecae* and spiralling whitefly, *Aleurodicus dispersus* have been recorded from coconut in recent times in India (Josephraj Kumar *et al.*, 2010). A gradient outbreak of coconut slug caterpillar, *Macroplectra nararia* was noticed in East Godavari district, Andhra Pradesh during April-May 2009 and was found closely interlinked with rise in ambient temperature and humidity along the water bodies (Rajan *et al.*, 2011).

A potential invasive pest of coconut palm viz., the coconut leaf

beetle *Brontispa longissima* (Gestro) has already reached the vicinity of our country in Maldives, Myanmar and China. To check the possible entry of such invasive pests to our country regular pest surveillance and also strict quarantine measures must be taken up on priority (Rajan *et al.*, 2009b).

#### Summary

Being a perennial crop, coconut provides a comfortable niche for a wide array of pests during all stages of its growth and these pests cause considerable damage resulting in huge yield loss to the crop. Effective IPM technologies with emphasis on biological control methods have been developed and field validated in larger areas. However, studies indicate that farmer-level adoption of these technologies is still in a low phase due to various reasons. There is an urgent need for modified and innovative extension strategies to create confidence among farming communities for technology adoption. Farmer Field Schools (FFS), technology adoption through cluster approach etc. can help in promotion of technology dissemination and adoption. The contiguous and homestead nature of coconut gardens and the high flight range of insect pests warrant the necessity for adoption of various technologies on a group approach mode as it will reduce the cost of operations and can produce sustainable results. Awareness on emerging and quarantine pests of coconut may be developed among the farming community for effective monitoring and follow up action in case of their occurrence.