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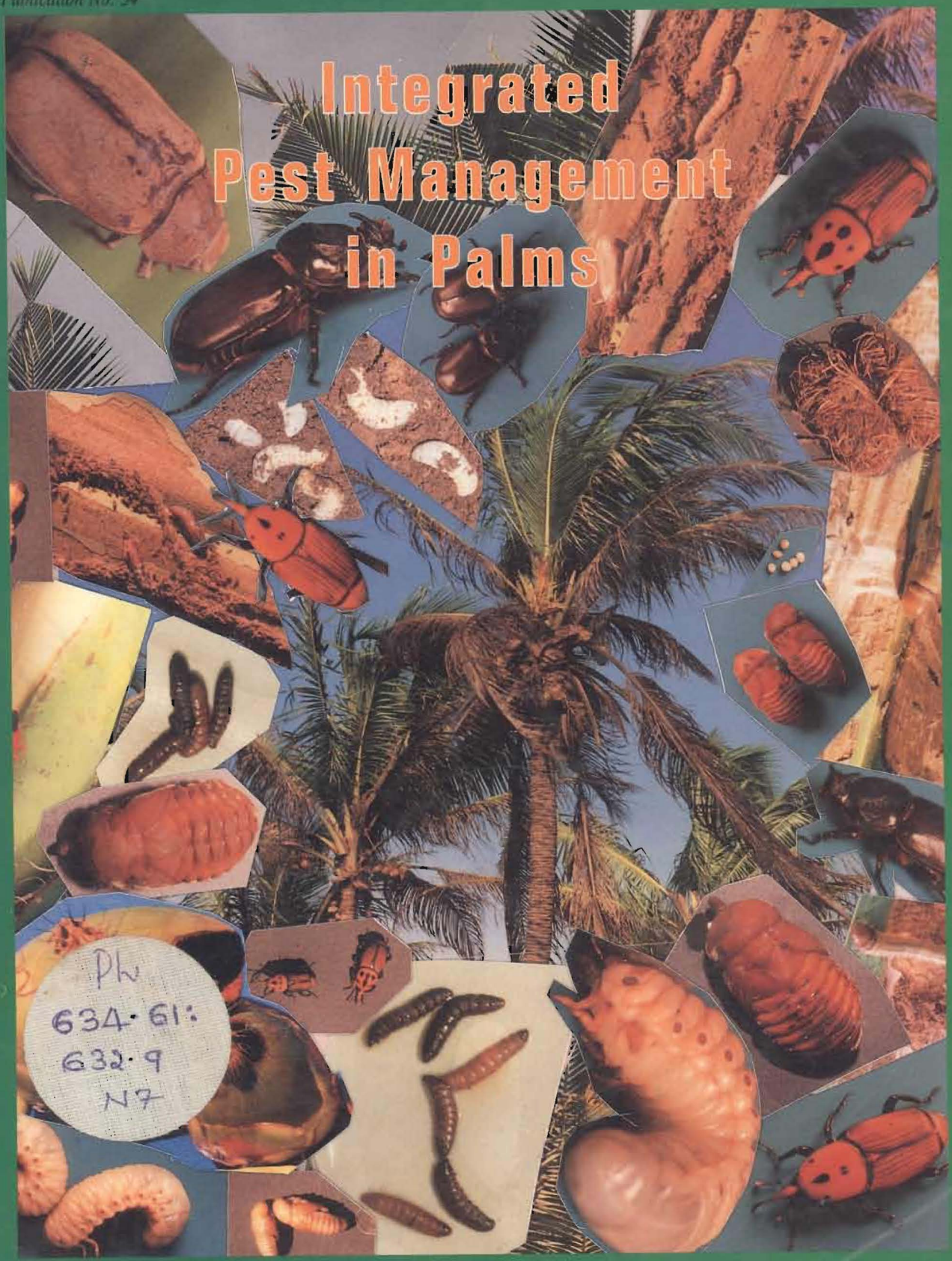
Integrated Pest Management in Palms



INTEGRATED PEST MANAGEMENT IN PALMS

INTEGRATED PEST MANAGEMENT IN PALMS

(Proceedings of the Entomology Group Meeting held at CPCRI, Kasaragod on 20 December 1995)

COCONUT DEVELOPMENT BOARD
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FOREWORD

It is estimated that about 12 per cent crop loss is caused by pests alone in different crops. The scenario is not different in the plantation crops. A wide range of pests are found damaging palms at various stages of their growth and about 100 species of various pests have been reported to damage coconut palm in India. Among them, rhinoceros beetle, red palm weevil, black headed caterpillar and white grub are the key pests. Arecanut and oil palm are also afflicted with different insect pests. A few of the pests are common to all the three palms.

Investigations have been in progress for the last few decades at CPCRI and also various State Agricultural Universities on different pests affecting palms and cocoa. As a result of systematic and intensive investigations, biology and bionomics of the major pests attacking palms and cocoa and their control measures have been evolved. The increasing use of pesticides naturally leads to environmental hazards and decreasing efficacy of the applied pesticides. This alarming situation is the inevitable reason for laying emphasis on research towards the use of fewer insecticides coupled with exploitation of ecofriendly biotic agents in the control of pests. CPCRI has been spearheading biocontrol of pests of plantation crops in the country and in developing integrated pest management programmes in this field.

Among the recommendations on the control of different pests emerged from CPCRI and various State Agricultural Universities, some are at variance, creating confusion among the farmers as to the use of the correct chemical for effective pest management. Moreover, some of the existing recommendations still include pesticides which are banned for agricultural use. Hence, the initiative taken by CPCRI in convening a group meeting of all the entomologists working on different plantation crops in various State Agricultural Universities and Central Institutes is timely. I am happy to note that this group meeting had the desired result of crystallising recommendations in the control of different pests of palms and cocoa.

This publication which gives in detail the biology and bionomics of different pests and management schedule will be quite useful not only to the research workers including students and extension agencies but also to the farmers cultivating these crops. The colourful photographs on some of the pests add to the value of the publication. I am convinced that this will be a useful addition to the literature on pest control in plantation crops.

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PREFACE

Coconut, arecanut and oil palm are the major crops of commercial importance among the palms. India commands premier position in the production of arecanut and of late in coconut. The red oil palm has now been introduced in the country on a commercial scale though confined to a few states, the performance of which can be assessed only in the years to come.

All these crops harbour a large number of pests which curtail their production and productivity, often threatening the survival of the plant itself. The gravity of the problem is more so in coconut which has a history in India since the post-vedic period. Since indiscriminate use of chemical insecticides to suppress the pests is not favoured the world over and the concept of eco-friendly cultivation with zero chemicals is gaining momentum now-a-days the management of pests through biotic or mechanical means is the alternative under such a situation. The mechanical and biological control therefore are to be preferred to wherever they are effective.

The entomology group meeting held at CPCRI, Kasaragod in December '95 was an opportune one to remove confusion among the farmers on the correct chemical to be used in the control of pests after the recent notification by the Government of India banning several plant protection chemicals hitherto used in the country. This publication is the result of detailed discussions among the entomologists in the meeting convened by the CPCRI. I hope that this publication with profuse illustrations with colour photographs will help the farmers as well as the extension workers to identify the pests in the field besides to plan an effective strategy to control them.

M. Aravindakshan
Chairman
Coconut Development Board

CONTENTS

LIST OF PHOTOGRAPHS

Integrated Pest Management in Palms

INTRODUCTION

India has a pride of place in the production of arecanut being the largest producer of arecanut in the world. India's position in coconut production in the world has been elevated to the second from third. The area under arecanut cultivation during 1992-93 was 0.22 million ha with a production of 0.248 million tonnes of arecanut. In the case of coconut the area is 1.63 million ha with 12.35 billion nuts production during 1993-94. Oilpalm is of recent introduction to India and the area is 0.017 million ha during 1994-95. Large scale plantations have been started only after 1988-89 and as such all of them have not started yielding. However, the production figures available for 1991-92 indicate that the production was 0.004 million tonnes. The production and productivity of these important commercial palms are often threatened by the incidence of various pests and diseases. Some of the pests which affect coconut or arecanut are common to oil palm also.

The Central Plantation Crops Research Institute has been engaged in investigations on the management of pests affecting these palms and has come out with appropriate technologies for combating them. The contributions from different south Indian Agricultural Universities on the control of pests especially on coconut have also helped in this direction. In some cases, the recommendations from different organizations for the control of pests are at variance which might create confusion among the farmers. The group meeting of scientists working on these crops in various scientific organizations was held in December 1995 at CPCRI Kasaragod under the Chairmanship of Dr. K.L. Chadha, Deputy Director General (Hort.) ICAR, and this has helped in unifying the recommendations for the control of different pests of palms.

This publication is an effort to bring together the recommendations from various centres in an unified form. At the end of the publication, details have been given about the various pesticides and the quantity to be used in 10 litre water while spraying against various pests (Appendix I).

I. COCONUT

Coconut palm is prone to infestation by a large number of pests. Among the insects recorded on coconut in India, the rhinoceros beetle (*Oryctes rhinoceros* L.) the red palm weevil (*Rhynchophorus ferrugineus* Fab.), the leaf eating caterpillar (*Opisina arenosella* Wlk.) and the white grub (*Leucopholis coneophora* Burm.) are the major pests occurring in most of the coconut growing tracts. Besides these, pests like scale insects, mealy bugs, coreid bug, defoliating caterpillars, termites etc. cause considerable damage at times, though generally they are of minor importance. Due to the changing scenario in agriculture, at least in certain parts of the country, coreid bug, mealy bugs and scale insects are becoming a menace threatening the crop. Rodents like rats and bandicoots also affect the coconut palm at various stages of growth.

1. Rhinoceros beetle: *Oryctes rhinoceros* Linn. (Scarabaeidae : Coleoptera)

Rhinoceros beetle is a serious and ubiquitous pest of coconut palm.

Damage

The adult beetle bores through the unopened fronds and spathes. The adult beetle which is the destructive stage of the pest also

infests palmyra, oilpalm, date palm, toddy palm, etc.

Symptoms

The affected frond, when fully opened, shows characteristic geometric cuts making the leaves unsuitable for thatching purposes (Fig.1).

Fig. 1. Rhinoceros beetle affected leaf showing geometric cuts

Infestation on spathe results in drying of the inflorescence (Fig.2). The pest is reported to cause an estimated yield loss of 5% every year. Moreover, the injured portions may attract pests such as red palm weevil and also pave way for fungal infection. Repeated infestation

Fig. 2. Rhinoceros beetle attack on spathe resulting in drying

to the growing points may eventually lead to the death of the seedlings.

Season

The pest is found throughout the season; however, its population is high during June to September.

Life cycle

The beetle breeds on decaying organic debris such as farm yard manure, dead coconut stumps and logs, compost, etc. The fully grown grub is ash grey with brownish hairs on

the body (Fig. 3). Pupation takes place in a cocoon. The life cycle is completed in about six months. Adult is a large stout-built black beetle with a cephalic horn which is very prominent in the case of males (Fig.3).

Fig. 3. Grubs and adults of rhinoceros beetle (left: male, right: female)

Management

Integrated management schedule has been found to be very effective and economical. This consists of:

(i) Sanitational method: The dead and decaying organic debris in the vicinity of coconut plantations may be properly disposed of since these act as prolific breeding grounds for the beetle.

(ii) Mechanical method: The adult beetles may be extracted using beetle hooks from the palm crown particularly during the peak period of population build up. The holes made by the beetles are to be filled with a mixture of fungicide and sand prepared at a ratio of 3 g mancozeb + 1 kg fine sand.

(iii) Prophylactic leaf axil filling: To protect the young palms from rhinoceros beetle attack, the innermost 2-3 leaf axils may be filled with a mixture of sevidol 8G (25g) + fine sand (200 g) per palm during May, September and December. Leaf axil filling with 10.5 g of naphthalene balls covered with sand at 45 days' interval is also effective.

(iv) Treatment of breeding sites: The breeding material such as cattle dung, compost and other decaying organic debris may be periodically treated with carbaryl 50% WP at 0.01 per cent on w/w basis.

(v) Biological suppression: Baculovirus of *Oryctes* and the green muscardine fungus cause diseases to the immature and adult stages of the beetle (Fig. 4 & 5).

(vi) Attraction and trapping using breeding material : Setting up of breeding traps using decaying organic debris treated with 0.1% carbaryl 3-4 times a year brings down the pest population.

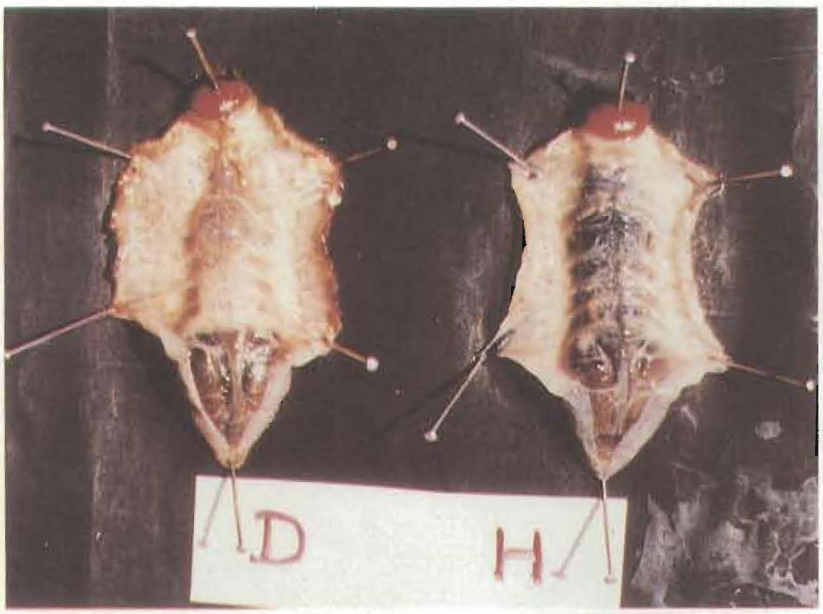

Fig. 4. Baculovirus affected diseased (D) and healthy (H) grubs of *O. rhinoceros* (dissected grubs)

Fig. 5. Metarhizium affected diseased (D) and healthy (H) grubs of *O. rhinoceros*

(a) The viral pathogen Baculovirus of *Oryctes*: The adult beetles are inoculated either by feeding the viral inoculum or by allowing the insects to crawl over the viral suspension. Release of such baculovirus inoculated beetles has to be done @ 10-15 beetles/ha of the plantation.

(b) The entomopathogen *Metarhizium anisopliae* (Metch.) Sorokin: This fungus could be mass cultured in coconut water or on cassava chips and rice bran supplemented with a nitrogen source. Treatment with the fungus is to be done during monsoon season. The fungus can be inoculated @ 5 x 10^{11} spores/m^3 of the breeding material.

2. Red palm weevil: *Rhynchophorus ferrugineus* Fab. (Curculionidae : Coleoptera)

Red palm weevil is a major pest of coconut in all parts of India.

Damage

The weevil attack is more serious in young plantations below 20 years. The pest can cause damage to the crown and stem portion close to the crown region. The bole region of seedling is also damaged by the infestation. The pest also infests oil palm, palmyra, date palm etc.

Symptoms

The symptoms of red palm weevil infestation become very clear in advanced

stage by which time the crown of affected palm topples (Fig. 6). On close monitoring it can be seen that the infested palms in the early stage show yellowing and later wilting of leaves of inner and middle whorls. Small circular holes can be seen on the trunk with a brownish viscous fluid oozing out from them. The bases

Fig. 6. Coconut crown affected by red palm weevil

of the affected leaves sometimes split and extrusion of fibres is seen from the cracks. The presence of chewed up fibres/cocoons/weevil, etc. in leaf axils, indicates the presence of the pest in the crown. Gnawing and nibbling sound produced by the grub inside while feeding is audible in many cases.

Season

The pest is observed in the field throughout the season but is serious after the South West Monsoon.

Life cycle

The weevil is a large sized ferrugineously brown coloured insect with a long curved and pointed snout (Fig. 7). The males are distinguished from the females by a tuft of hairs on

Fig. 7. Red palm weevil adult

the dorsal side of the snout. The female weevil scoops out small holes in soft tissues and lays the eggs. Eggs hatch in two to three days time into soft white legless grubs and they bore into the interior of palms (Fig. 8). Feeding on the growing point by the grubs results in death of the palm, if left unnoticed. The grubs pupate in cylindrical cocoon made out of fibrous strands. The whole life cycle from egg to adult takes about 4 months (Fig. 9).

Management

For the management of red palm weevil an integrated approach involving all proven methods of control is quite feasible. This includes:

Fig. 8. Tunnelling by red palm weevil grubs into soft portion of coconut petiole

Fig. 9. Life stages of red palm weevil

(i) Sanitational and cultural methods:

a) The palm crown has to be cleaned periodically to avoid decaying of organic debris in leaf axils. Dead palms which lodge various stages of the weevil should be removed, cut open and burnt so as to destroy all stages of the pest thereby preventing spread of the weevil to neighbouring healthy palms.

b) As far as possible avoid making any cuts causing injuries to the palm as these will attract weevils for egg laying. The cuts or injuries if any, may be treated with coal tar + carbaryl.

c) When fronds are to be removed from the palm, it should be cut leaving a petiole length of 120 cm. This will avoid entry of the pest into the trunk portion.

d) Palms affected by bud rot and leaf rot diseases and rhinoceros beetle may be properly treated with respective fungicides and insecticides.

(ii) Insecticidal treatment

a) Prophylactic method

Prophylactic leaf axil filling may be given to the palms with insecticide-sand mixture as advocated against rhinoceros beetle (vide iii under control of rhinoceros beetle).

b) Curative treatment:

The affected palms in early stages of infestation could be saved by injecting 0.1 per cent endosulfan/dichlorvos or 1 per cent carbaryl. Depending on the intensity of pest infestation about 1000-1500 ml of insecticide suspension may be required for one palm. In the case of crown damage, the damaged tissues have to be removed and the insecticide suspension may be poured in. When pest entry is through the trunk all the holes on the stem may be plugged with cement or plaster and allowed to set. A slanting hole just above the portion of serious damage may be made with an auger. The insecticide suspension is gradually poured in using an injector or funnel till the required fluid has percolated in. Depending on severity of infestation, additional holes may be drilled at other sides and the insecticide may be applied.

(iii) Attraction and trapping:

a) Log trapping with toddy:

Fresh coconut logs, 50 cm long, split longitudinally and the cut surfaces smeared with fresh toddy fermented with yeast or acetic acid are effective in attracting the weevils. The traps are set in such a way that the two split halves are placed one above the other with their cut surfaces facing each other. Pieces of fresh coconut petioles smeared with fermented toddy and kept in pots also serve as a weevil trap. Such traps in the garden should be set up in the evening and the weevils can be collected and destroyed next day morning. About 10 such traps are to be placed in one ha area of the garden.

b) Mud pot trapping with molasses:

Mud pots containing sugarcane molasses 2.5 kg/toddy 2.5 litres + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petioles of leaves, at the rate of 75 numbers in one ha are effective in trapping adult weevils in large numbers.

3. Leaf eating caterpillar, *Opisina arenosella* Wlk. (Oecophoridae: Lepidoptera)

The leaf eating caterpillar or the black headed caterpillar is a major pest in all coconut growing areas of India.

Damage

The larva of this insect feeds on the under surface of the leaflets resulting in considerable reduction in the photosynthetic area of the palm. Severe infestation of the palms by the pest affects the yield very much. Apart from coconut the pest is also reported to feed on palmyra, talipot palm, wild date and ornamental palms.

Symptoms

The caterpillar lives on the lower surface of leaflets in galleries made of excreta and silken web and feeds on the chlorophyll containing parenchymatous tissues (Fig. 10). Dried up and green patches appearing on the upper epidermis of leaves and presence of larval galleries, moults and pupal cases on the lower surface of the leaves are the major symptoms of infestation. In cases of severe infestation the whole plantation presents a scorched appearance (Fig. 11).

Season

The pest is present throughout the year, but their population increases considerably during summer months mainly due to favourable temperature and humidity conditions.

Life cycle

The fully grown larva is about 15 mm 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; female moth measures 10-15 cm long with a wing spread of 20-25 mm. The total duration of the pests from egg to adult stage (Fig. 12) is completed in about two months.

Fig. 10. *Opisina* damage on coconut leaflets

Fig. 11. Coconut palms severely infested by *Opisina*

Fig. 12. Life stages of *O. 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 outbreak. The integrated pest management (IPM) method consists of the following:

(i) *Mechanical*: Cutting and burning the heavily affected and dried outermost 2-3 leaves.

(ii) *Biological method*: Promising parasitoids may be released at the fixed dosages depending on the target stages of the pest at fortnightly intervals till the pest population is suppressed (Fig. 13):

Fig. 13. Parasitoids of *O. arenosella*

Release Bethylid, *Goniozus nephantidis* for 3rd larval stage or above; Elasmid, *Elasmus nephantidis* for prepupal stage and Chalcidid, *Brachymeria nosatoi* for early pupal stage. Larval parasitoid *Bracon hebetor* (Braconid) and pupal parasitoid *Xanthopimpla punctata* (Ichneumonid) can also be used as promising parasitoids. In a multistage condition of the pest, combined release of all the parasitoids is required. When an initial insecticide treatment is given, the parasitoids may be released after 3 weeks of spraying.

(iii) *Curative*: During severe sporadic outbreaks the pest can be checked to a lower level by spraying with any one of the following insecticides viz; dichlorvos (0.02%) or malathion/endosulfan/phosalone, each at 0.05%.

In case of severe epidemic outbreaks when the survival of the palm is threatened and if all other methods are not feasible, application can be done through root feeding or stem injection. In such cases, all mature nuts may be harvested before treatment and plucking tender coconuts or harvesting of nuts should be strictly avoided for fourty days after treatment.

a) *Root feeding (in sandy loam areas):* Select an active live root, make a slanting cut and insert the root in the insecticidal solution containing monocrotophos 36 wsc-10 ml + water - 10 ml in a small polythene bag. Secure the bag tightly to the root with a thread.

b) *Stem injection (in laterite soil areas where root exposure is difficult):* A downward slanting hole (7-8 cm depth) is drilled and 10 ml of Monocrotophos 36 wsc injected into the stem at about 1 m above the ground level and the hole plugged with clay mixed with copper oxychloride.

4. White grub: *Leucopholis coneophora* Burm. (Melolonthinae : Coleoptera)

The white grubs are one of the major pests of coconut palm found mostly in sandy loam tracts of Kerala and Karnataka.

Damage

The pest damages mainly roots of palms and also tunnels into the bole and collar region of the seedlings.

Symptoms

The grubs feed on the roots of coconut palm and also tubers, rhizomes, vegetables, etc. grown as intercrops. The attack on the nursery seedlings results in drying up of the spindle leaf followed by gradual death of the seedlings. Holes can be seen at the collar region/bole of the affected seedlings. In mature coconut trees, continuous infestation by the grubs results in yellowing of leaves, tapering of crown, premature nutfall, delayed flowering, retardation of growth and reduction in yield.

Season

Peak population is seen in the coconut basin during September-October. Adult beetles emerge out of the soil after pre-monsoon showers in May-June.

Life cycle

The grubs are creamy white in colour with a brown head.

Adult beetles are of chestnut brown colour (Fig. 14). Eggs are laid in soil where the pest undergoes different stages. It has an annual life cycle with a grub period of 8 months.

Management

i) Deep ploughing and digging of the soil during pre and post monsoon periods to expose the different stages of the insect

Fig. 14. Adult beetle and grub of white grub (*L. coneophora*)

for predation by birds and other animals.

ii) Collection and destruction of the adult beetles during the peak period of emergence in May-June.

iii) Setting up of light traps to attract adult beetles.

iv) Insecticides like phorate 10 G may be applied @ 100 g/ palm in May-June and September-October so as to cover pre and post monsoon periods in coastal/ malanad areas. In places where rainfall is distributed only during September-November period, the time of application of pesticide may be fixed to coincide with rainfall. The insecticide has to be applied in the active root zone of the palm evenly leaving a distance of 60 cm from the base of the trunk. The granule has to be well raked and mixed with the soil. There should be adequate moisture in the basin after the insecticide application.

MINOR PESTS

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

The adults and nymphs feed on buttons and developing nuts. They suck up the sap by piercing the stylet into the tissues just below the perianth. The feeding marks later develop into brown lesions. Infestation results in immature nutfall and also formation of malformed nuts with cracks and crinkles on the surface (Fig. 15). Gummosis is also seen on the infested nuts. Maximum pest incidence is noticed in post monsoon period.

The adult is a brown coloured large bug measuring about 2 cm in size. Nymphs are ant-like and reddish brown in colour. The life cycle is completed in 25-34 days.

Spraying the crown with 0.1% carbaryl/endosulfan is recommended to control the pest. Bunches and leaf axils where nymphs and adults remain hidden are to be sprayed for effective control. The spraying has to be

Fig. 15. Malformed nuts due to infestation by coreid bug (adult bug is shown in the inset: enlarged size)

repeated after an interval of 45 days if required. Spraying may be done in the afternoon. Inflorescences which have just opened and buttons of receptive stage are to be avoided while spraying.

6. Scale insects: *Aspidiotus destructor* Sign., *Aonidiella orientalis* Mask and *Lepidosaphes megregore* Banks (Diaspididae)

Infestation of scales is seen on leaves, buttons and rachillae. The infested leaves turn yellowish and dry up. Button shedding is noticed from infested palms. The pest incidence is at its peak during summer months. In severe cases of infestation spraying with 0.1% fenthion/ malathion is recommended. A second spray has to be given after 30 days' interval. Among the many natural enemies noticed in association with scale colonies, the lady bird beetle *Chilocorus nigritus* Fab. is a potential predator effecting good natural control.

7. Mealy bugs: *Palmicultor palmarum* Ehrhon, *Pseudococcus cocotis* Maskal and *P.longispinus* Targ. (Pseudococcidae)

Mealy bugs colonize on all tender plant parts like bases of spear leaf, spadix, inflorescence and inside the perianth of nuts (Fig. 16). The presence of the insect is indicated by the appearance of the waxy white powdery coating. The pest infestation if left unchecked results in deformation or suppression of heart leaf. The spadix remains stunted and in severe cases of infestation immature nut fall is also observed. Ants which are found in association with mealy bugs help in their dispersal.

Spraying the seedlings with 0.05% monocrotophos or 0.1% fenthion, and the yielding palms with 0.05% dimethoate or phosphamidon or 0.025% methyl demeton are recommended to control the pest.

Fig. 16. Mealy bug colony on spear leaf

8. Mites

Red mites, *Raoiella indica* (Hirst), the spider mites *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/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) provisions of adequate shade and irrigation will help in reducing the mite incidence in seedlings.

9. Slug caterpillars: ***Contheyla rotunda*** **H.** is noticed in the west coast of India. Besides coconut, it feeds on banana also. The caterpillar is slug like with spines on the body. The life cycle is completed in 40 to 58 days. The larva feeds on the entire lamina leaving behind only the midribs. The other slug caterpillars are *Parasa (Latoia) lepida* Cram and *Macroplectra nararia* Moore. These pests can be controlled with 0.1% carbaryl/endosulfan spray.

10. Rodents

There are two types of rodents (arboreal and burrowing) damaging coconut. The arboreal black rat *Rattus rattus wroughtoni* Hinton is nocturnal and live mainly on the crown of palms. They move from palm to palm through the fronds and seldom come to the ground. They breed throughout the year with peaks during February-March and July-August. They make small holes (about 5 cm diameter) near the perianth region of tender nuts and feed on the inner contents (Fig. 17). The damaged nuts fall from the attacked bunch. Nuts of 3 to 6 month maturity are

Fig. 17. Rat damage on tender coconut

mostly preferred. Unopened spathes, female flowers and leaf stalks are also attacked.

The burrowing rodents (Lesser bandicoot : *Bandicota bengalensis* Gray; larger bandicoot : *B. indica* (Bechstein) and the gerbil: *Tatera indica* Hardwicke) make extensive burrows in the soil and live inside. These rodents damage the coconut seedling and eat away the cabbage portions.

Management

i) *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.

ii) *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.

iii) *Trapping* : Trapping using live or death traps is the safest but labour intensive method for controlling rodents. Bamboo traps or tube can be effectively utilized against burrowing rodents damaging seedlings (Fig.18).

iv) *Poison baiting* :

a) Single dose anticoagulant : bromodiolone (0.005%) : placement of 10 g of 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 *R.r. wroughtoni*. If the damage is restricted to certain palms, only such palms require baiting.

b) Zinc phosphide : The bandicoots and gerbils are effectively controlled by poison baiting using zinc phosphide. 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 pieces or 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 over come the problem of bait shyness plain baits (without poison) should be kept in each 'active' burrow for 2-3 days before putting poison bait.

11. Nut borer : *Cyclodes omma* V (Noctuidae) and *Tirathaba* sp. (Pyralidae)

The catterpillars of these insects bore into developing buttons at the perianth portion (Fig.19) causing nut drop. The pest can be controlled by either hand picking and destroying or by spraying 0.1% carbaryl.

12. Shot hole borer: *Xyleborus perforans* E. (Scolitidae)

The beetle makes numerous minute

Fig. 18. Different types of traps used for trapping rodents

Fig. 19. Coconut buttons infested by nut borer caterpillar

holes on the bark. The pest is found to be serious in parts of Tamil Nadu (Ramanatha puram district). The pest can be controlled by stem injection of 0.2% fenthion/ dichlorvos. Swabbing the bark with 0.1% chlorpyriphos also is effective in controlling the pest.

13. Termites (white ants): *Odontotermes obesus* Ramb (Termitidae)

Termites cause serious damage to nursery seedlings and adult palms. They feed on the husk portion of the nuts and collar region of the seedlings resulting in the wilting of central shoot. In older palms the termite attack is observed on the bark and sometimes on the crown region. For the management of termites adequate soil moisture is a pre-requisite. Drenching the nursery with 0.05% chlorpyriphos twice at 20-25 days interval is recommended. The affected trunk may be swabbed with the above chemical.

II. ARECANUT

Areca palm is attacked/ colonised by a number of insects right from the nursery onwards. Many of them are major pests resulting in the death of the palms in the nursery/main field, loss of yield and sometimes in the complete loss of palms. They infest all parts of the palm such as roots, stem, foliage, inflorescence and nuts. The population of many of these insects could be reduced to a manageable level by selecting ideal sites of plantations, discriminate use of insecticides and augmentation of natural enemies.

The nature of attack, the symptoms of attack and management measures suitable and economical for the major and locally important insect pests are described below.

1. Phytophagous Mites

Mites enjoy a wide distribution in all areca growing tracts of India. They are polyphagous pests found on other palms also.

i. Palm/red mite, *Raoiella indica* Hirst (Acarina : Tenuipalpidae), Cholam/White mite, *Oligonychus indicus* Hirst (Acarina : Tetranychidae).

Fig. 20. A. Red mite colony with predators

Damage

Adults and nymphs of these mites colonise the lower surface of leaves and suck the plant sap.

Symptom

Leaves show yellow speckles initially as a result of feeding which later coalesce, become bronze coloured and finally the leaves dry up and wither away (Fig. 20 A, 20 B). In severe attack, the mites suck the sap from any green portion of plant including tender nuts.

Season

Summer months but present throughout the year in low population.

Life cycle

The total duration of the immature stages of white mites varies from 6.5 to 9 days. The female mite lays an average of 3-4 eggs per day for an oviposition period of 10.1 days.

The life cycle of female and male red mites is completed in 12.9 days and 11.2 days respectively during April-May.

Management

Provide shade to nursery seedlings and young palms in the field. Provide adequate irrigation in summer months. A number of indigenous natural enemies like

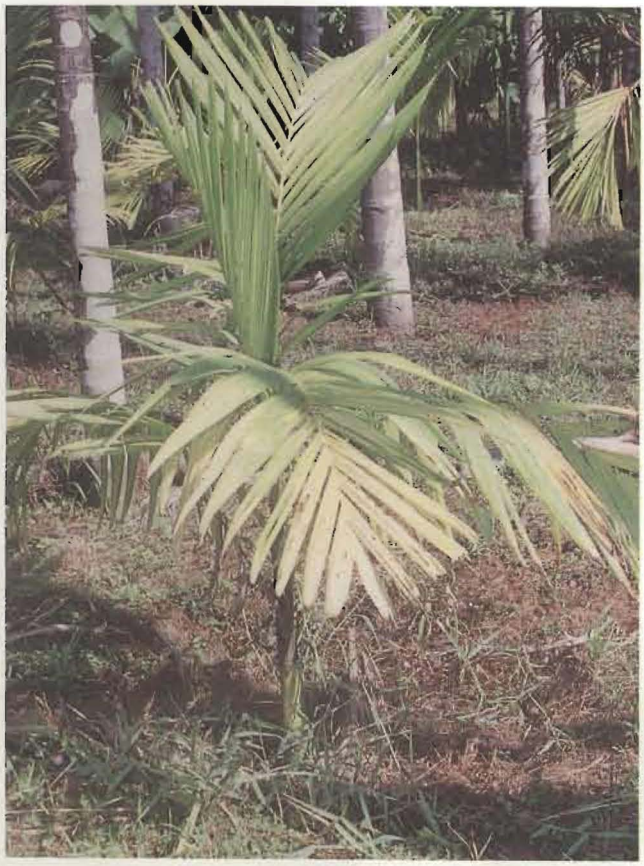

Fig. 20. B. Mite infested areca seedling

coccinellid beetles, mites, thrips etc. are present in nature and these natural enemies exert good control of the mites. In cases of severe attack on young palms and nursery seedlings, spray the under surface of leaves with 0.05% dicofol/ dimethoate.

ii) Calyx/Orange mite, *Dolichotetranychus* sp. (Acarina : Tenuipalpidae)

Symptom

Suck the sap from inner whorls of perianth of tender nuts. Feeding causes shedding of tender nuts.

Season

Summer months. Recorded from Thrissur.

Management

Spray dimethoate 0.05% conc.

2. Spindle bug, *Carvalhoia arecae* Miller & China (Hemiptera : Miridae)

The spindle bug infestation is noticed in Kerala and Karnataka; but the damage is high in South Kerala.

Damage

Adults and nymphs living inside the inner most leaf axil at the base of the spindle suck sap from tender spindle and tissues of younger leaves (Fig. 21). They damage the plants from nursery stage onwards.

Symptoms

Damaged leaves show linear water soaked lesions which turn to dark brown lesions and become necrotic patches later and dry up and drop off. Affected spindles show characteristic linear brown lesions (Fig. 22) and badly infested spindles do not open completely.

Season

Throughout the year, more from June to October.

Life cycle

Adult bugs are red and black, while nymphs are greenish yellow with light yellow head and scarlet red eyes. Life cycle is completed in 32-34 days.

Management

Spray dimethoate 0.05% in and around the spindle and inner whorls of leaves in the morning or evening hours of the day in gardens with initial infestation by these bugs. In gardens having incidence of this bug in contiguous years, the following method of control should be adopted. Tie polyethylene sachets (perforated and heat sealed) containing 2g phorate (10 G) granules to the inner most

Fig. 21. Adult of spindle bug seen in the innermost leaf axil of arecanut

Fig. 22. Symptoms of spindle bug attack on areca spindle

two leaf axils. As and when new spindles emerge, the sachets are transferred to the youngest leaf axils.

3. Root/White grubs, *Leucopholis burmeisteri* Brencke (Coleoptera : Scarabaeidae)

The root grubs are voracious feeders on areca roots and are polyphagous in nature. They are found in all areca growing areas.

Damage

Grubs feed on tender and mature roots of the palms; (Fig. 23) in severe cases of incidence, the bole of the palm is also eaten up. These polyphagous insects feed on roots of intercrops and grasses in areca gardens. They occur in low lying and clayey soils with high water table.

Symptoms

Continuous feeding on roots results in yellowing and drooping of leaves, tapering of stem and reduction in yield. Palms succumb to attack, if unchecked.

Fig. 23. Grubs of *L. burmeisteri* attacking roots of arecanut palm

Season

Throughout the year; perennial and location specific.

Life cycle

The root grub has an annual life cycle, with a prolonged grub period of 7 to 8 months. The grubs are U shaped (Fig. 23). Adult is a medium sized beetle with a chestnut brown colour (Fig. 24).

Management

Good drainage to be provided in the garden. Collect adult beetles during emergence period ie. after 8-10 days of premonsoon showers between 6.30 to 7.30 pm daily when these beetles will be emerging from the soil. Apply 15 g phorate 10 G per palm twice a year in May-June and September-October for a duration of minimum three years. Enough moisture should be available in the garden

Fig. 24. Adults of *L. burmeisteri*

when the application of insecticides is done. The insecticide should be raked up into the soil. Cultivation practices like basin opening help in detection and predation action.

4. Inflorescence caterpillar, *Tirathaba mundella* Walker (Lepidoptera : Pyralidae)

Damage

The adult moths lay eggs in the mechanically damaged portions of the spadices and the emerging caterpillars feed on the inflorescences especially the tender female flowers and rachillae, and web together the rachillae into a wet mass (Fig. 25).

Symptom

Spadices do not open in time as a result of the webbing together of the inner parts. Yellowing of the spadices, presence of small holes with frass and drying patches on the spathe are the external symptoms of attack.

Season

Throughout the flowering season.

Life cycle

The egg period lasts for 5 days and the larval period for about 26 days covering 5 instars. Pupal period lasts for 9-11 days.

Fig. 25. Arecanut inflorescence infested by *Tirathaba mundella*

Management

Damage caused by slugs on tender spadices is a predisposing factor to the attack by this caterpillar. The control measures include collection and killing of slugs, force opening the infested spadices and spraying malathion (50 EC) at 0.05% conc., if the damage is partial. If the female flowers are damaged, the spadix should be removed and burnt.

5. Pentatomid bug, *Halyomorpha marmorea* (Hemiptera: Pentatomidae)

Damage

The later instar nymphs and adults of this bug pierce the tender nut and suck the kernel sap.

Symptom

Premature drop of nuts; shed nuts show a pin-prick black puncture mark below the perianth or on the nut surface. When cut open, the inner tissues beneath the puncture mark show decay (Fig. 26).

Fig. 26. Tender arecanut attacked by *H. marmorea*

Season

March - July months

Management

Collect these bugs when seen on alternate host plants like chillies, lady's finger, bittergourd etc. and destroy. In heavy infestation, spray the bunches with endosulfan 0.05%. Spraying should be given according to the incidence and severity of the bug in a garden, first round in April-May and the second round 45 days after.

6. Scale insects *Aonidiella orientalis* (Homoptera : Diaspididae)

Damage

The scale insects colonise the leaves, spathe, leaf sheaths and bunches and suck sap from the plant tissues.

Symptom

Continuous feeding results in premature yellowing of nuts (Fig. 27) and in cases of severe infestation, the kernel may not develop and turn black.

Season

Throughout the year, but more serious during October to February.

Management

Scale insect outbreaks occur in arecanut gardens in some years mainly as a result of indiscriminate and incorrect usage of insecticides. In nature many species of natural enemies like coccinellid beetles, thrips, predaceous mites and parasites occur which help in the suppression of scale population to an extent. Release of coccinellid beetles could be done periodically in gardens having scale insect problems. Spraying with insecticide (Malathion 0.1% or Fenthion 0.1%) should be given with utmost care and it should be need based.

The areca palm is infested in some localities by the stem weevils, leaf thrips, case worms etc. which are considered as minor pests and control of these through insecticides should be taken up only if the infestation is locally serious.

Fig. 27. Scale insect on arecanuts

III. OIL PALM

In recent years the red oil palm, *Elaeis guineensis* Jacq. is being extensively cultivated in Andhra Pradesh, Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu and Andaman and Nicobar Islands. Many of the pests occurring on coconut or areca palms are slowly getting adapted to oil palm. Insects, birds and mammals damaging seedlings, young palms and fruits are emerging as major problems for oil palm in India. For most of the pests there are a large number of biotic agents which are to be used advantagenously. Indiscriminate use of chemical insecticides may upset the natural balance and adversely affect the beneficial insects like pollinating weevils. Insecticides should be applied only if other options are not available. Field sanitation is an integral part of pest management. Hence it is advisable to adopt an integrated pest management programme incorporating mechanical, sanitational, chemical and biological methods for the effective management of the pests of oil palm.

Fig. 28. Spindle bug attack on oilpalm spindle

NURSERY

1. Spindle bug, *Carvalhoia arecae* Miller and China (Heteroptera : Miriidae)

Damage

Nymphs and adults suck sap from the spindle and tender leaves. Generally noticed in nursery seedlings and young palms at Palode (Kerala) and Charmady (Karnataka).

Symptoms

A longitudinal, narrow discoloured zone is formed on the sides of the feeding point. When the leaves open, the feeding marks can be seen as the necrotic lesions (Fig. 28). These lesions later turn into dry brown patches. In severe case of infestation the spindle fails to open.

Season

Highest incidence is noticed during June and lowest in February.

Management

The infestation can be brought down with 2 g of phorate 10 G (Thimet) taken in heat

sealed polythene sachets (5 cm long). The sachets containing the insecticide are pin pricked and placed on the top most two leaf axils (one sachet per axil). These are to be transferred to the youngest leaf axils as and when new spindles emerge. The same sachets can be used for 6-8 months.

2. Tussock caterpillar, *Dasychira mendosa* Hubner (Lepidoptera: Lymantriidae).

Damage

The pest was found to feed voraciously on young and mature leaves in the oil palm nurseries in Palode (Kerala) and in Shimoga (Karnataka). The caterpillars are polyphagous and can be identified by the presence of dense tufts of hair growing forward and backward.

Symptoms

The larvae feed on the leaves causing defoliation. The percentage of seedlings defoliated ranges from 3-20 in various places.

Season

Infestation is noticed throughout the year but is the highest during June-July coinciding with the onset of heavy rains.

Management

The caterpillars can be controlled by spraying with Carbaryl 50% WP 0.01% after cutting and burning the badly infested leaves.

3. Pink shoot borer, *Sesamia inferens* Walker (Lepidoptera: Noctuidae).

The pest was found on oil palm seedlings in the primary and secondary nurseries of Honnali (Karnataka). Caterpillars tunnel into the stem through the spindle leaf rachis and reaches the meristematic tissues arresting the growth, producing dead heart and little leaf symptoms.

Spraying Carbaryl 50% WP 0.01% at bimonthly intervals will bring down the pest incidence.

ADULT PLANTATION

4. Rhinoceros beetle, *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae)

Damage

The pest is noticed in all the oil palm growing areas. Infestation is severe in plantations where oil palm seedlings (Fig 29) are under-planted in coconut garden and where field hygiene and sanitation are poor.

Symptoms

Beetles bore into the base of spear cluster resulting in the breaking of spindle at the base. The leaves which emerge subsequently become shortened, and distorted. The beetles bore into immature male and female inflorescences even when they are inside the spathe (Fig 30). The damage to the heart of the palm paves way for the entry of fungi and bacteria, which induce rotting in the bud. The injuries serve as sites of egg laying for red palm weevil.

Season

Peak period of adult emergence is from June to September.

Management

An integrated approach is required to combat the pest. Beetles which burrow deep into the crowns of young palms can be extracted by means of a hooked pointed metal rod (beetle hook). After extraction of the beetle the leaf axils around the injured spindle/leaf is to be filled with a mixture of mancozeb and fine sand at a ratio of 3 g: 1 kg. Prophylactic leaf axil filling is to be done during April-May, September-October and December-January using Sevidol 8G @ 25 g per palm per application mixed with 200 g of fine sand. All potential breeding sites are to be eliminated from the plantation or to be sprayed with Carbaryl 50% WP (Sevin) 0.01% (on W/W basis). Application of the entomopathogen

Fig. 29. Nature of damage by rhinoceros beetle on oilpalm seedling

Fig. 30. Rhinoceros beetle attack on spathe

Metarhizium anisopliae in the breeding sites is very effective for the control of grubs. Release of baculo-virus infected adult beetles is the most economical, effective and easy method for dissemination of the inoculum into the natural population of the beetles. Castor cake fermented in rice water and kept in mud pots at ground level is an effective method for trapping adult beetles.

5. Red palm weevil (*Rhynchophorus ferrugineus* Oliver (Coleoptera: Curculionidae)

Damage

Damage is mainly due to the feeding activity of the grubs which bore through and feed on the soft tissues of stem, meristem and mesocarp of the fruits of ripe bunches (Fig. 31).

Fig. 31. Fruits of oilpalm fed by red palm weevil grub

Symptoms

Infestation is noticed in the oil palm plantation of Palode and Chithara (Kerala), Manvi (Karnataka) and Eluru (Andhra Pradesh). Being concealed in plant tissue, the pests can be detected only at a very late stage. Infested palms show gradual wilting and drying of outer whorl of fronds. Infestation if left unchecked results in death of affected palms.

Season

Pest is found through out the year.

Management

Prophylactic and sanitational control measures are required for red palm weevil management. Ripe bunches are to be harvested in time. Avoid making wounds on the palm. Prophylactic leaf axil filling with insecticide as in the case of rhinoceros beetle is to be done. Trunk injection with Carbaryl 50% WP at 1% or Endosulfan 35 EC at 0.1% is an effective curative treatment. The weevils are trapped and destroyed using split logs of coconut/oil palm or petioles (60 cm in length) treated with suitable attractant. Coconut toddy, macerated grapes, cashew apple, pineapple, crushed sugarcane and molassess can be used either singly or in combination with yeast or acetic acid as attractants.

6. Minor Pests

i) Nettle caterpillars and Bagworms

The nettle caterpillars, *Thosea* sp. (Lepidoptera: Limacodidae) cause severe defoliation on oil palms. Frequent outbreaks by *Thosea andamanica* Holloway occur in Little Andaman Islands. Occasional infestation by the bagworm, *Manatha albipes* Moore and *Metisa plana* (Lepidoptera: Psychidae) cause defoliation on oil palms at Eroor and Palode (Kerala) and Eluru (Andhra Pradesh). In Little Andaman Island, *Metisa* sp. and *Eumeta* sp. cause severe defoliation due to frequent outbreaks (Fig. 32).

In severe case of infestation, spraying with Carbaryl 50 % WP at 0.1% is recommended after cutting and burning the badly affected and dried leaves. Spraying should be timed to coincide with the maximum occurrence of young larvae, which are more sensitive to insecticides.

ii) Mealy bugs and scale insects

Pseudococcids (*Dysmicoccus brevipes* (Ckll.), *Pseudococcus citriculus* and *Palmicultor* sp.) and the Margarodid (*Icerya aegyptiaca*) infest the spear leaves of oil palm seedlings in the nursery and main field resulting in yellowing of young leaves and stunted growth of

Fig. 32. Nature of damage by bag worm

palms. Diaspids, *Ischnaspis longirostris* (Signoret), *Chrysomphalus aonidum* Linn. and *Aspidiotus destructor* encrust oil palm leaves. Diaspids, *Hemiberlesia lataniae* (Signoret), *Chrysomphalus anodium* Linn. and *Pinnaspis aspidistrae* (Signoret) and Pseudococcid, *Dysmicoccus brevipes* (Cockrell) infest unripe and ripe oil palm fruits. *D. brevipes* also infest the pre-anthesising male and female inflorescences (Fig. 33).

Infestation by mealy bugs can be controlled by spraying with Phosphamidon/ dimethoate at 0.05% or methyl demeton at

Fig. 33. Mealy bug attack on female inflorescence

0.025%. Scale insects can be controlled by spraying with Fenthion/malathion 0.1%.

iii) Aphids

Colonies of aphids like *Mysteroneura setariae* and *Schizaphis rotundiventris* (Homoptera : Aphididae) occur on the under surface of leaves and suck sap from them. In nursery and young palms they cause quite marked twistings and distortions of the spears.

Spraying with dimethoate 0.04%/phosphamidon 0.02%/malathion 0.05% on the under surface of leaves is recommended for the control of aphids.

iv) Proutista moesta (Westwood (Homoptera : Derbidae)

Occurrence of this plant hopper is noticed in all the oil palm growing areas. They suck sap from the leaves. They attain importance, as they are vectors of Mycoplasma-like organisms (MLOs) in palms.

Since the plant hoppers breed on the decaying materials, field sanitation is essential for the control of plant hoppers. Spraying with Endosulfan 35 EC 0.1% on the under surface of leaves (where the plant hoppers harbour) is recommended for the control.

v) Cockchafer beetles

Cockchafer beetles, *Apogonia* sp. (Coleoptera : Melolonthidae) and *Adoretus* sp. (Coleoptera : Rutelidae) make short the feeding holes in the older leaves of nursery and field planted young seedlings.

Ploughing and digging during pre-monsoon and post-monsoon period and collection of adults during the period of emergence are effective control methods. In severe case of infestation insecticide application with Phorate 10 G (Thimet) @ 50 g/palm in May-June and September-October is recommended. The insecticide will have to be applied to the soil in the root zone and raked into the soil.

vi) Termites

Pericapritermes sp. and *Hypotermes* sp. feed on the root of seedlings in polybags in Karnataka resulting in stunted growth. *Odontotermes* sp. infest the spear leaves, male inflorescence and fruit bunches in the field in Andhra Pradesh. Drenching with Chlorpyriphos 0.05% is recommended for the control.

VERTEBRATE PESTS

Birds

Birds such as crows (*Corvus splendens protegatus; Corvus macrorhynchus culminatus*), Mynah (*Acridotheres tristis*), Babbler (*Turdoides affinis affinis*), Parrots (*Psitticula krameri manillensis*) feed on the mesocarp of fruits causing an estimated fruit loss up to 2.8 t/ha/year (Fig. 34).

The ripe fruit bunches after 150 days of fruit set are to be covered with wire net of 1.25 cm mesh (60 x 90 cm size), reed baskets, plaited coconut leaf baskets or oil palm leaves to avoid bird damage. Covering the bunches with oil palm leaf tips and tying with a piece of rope to keep them firm and impenetrable by the bird beak is found to be effective and cheap.

Mammals

Black rat, *Rattus rattus wroughtoni*; House rat, *Rattus rattus rufescens*; Lesser bandicoot, *Bandicota bengalensis*; larger bandicoot, *Bandicota indica*; Indian gerbil, *Tatera indica cuvieri*; Western Ghat squirrel, *Funambulus tristriatus* and Porcupines, *Hystrix indica* attack oil palm at various stages of its development. Among them the burrowing rat is more dan-

Fig. 34. Nature of damage by birds on fruit bunches

gerous. It tunnels into the bole of the seedlings causing even their death. In mature palms rats eat the ripe bunches and gnaw the exposed pericarp of unripe and ripe fruits. Rats also destroy spikelets of the male inflorescences while feeding on the larvae and pupae of pollinating weevils.

Damage to young seedlings can be prevented by placing barriers consisting of 1.25 cm mesh (chickenwire mesh) collars around their base. They must be tightened around the palm and well fastened down to prevent the rats getting inside or underneath the guards. Baiting with zinc phosphide, Bromadiolone and traps such as iron live traps, deathfall trap, bow trap etc. may be used as an integrated approach to minimise the rodent damage to oil palm.

Wild boar - *Sus scrofa*

Wild boar digs up newly planted seedlings and chew them up. They also eat away the fruits from the bunches on the tree when they are accessible.

A local wild boar scaring device has been developed to scare away wild boar from entering nurseries and young oil palm plantations. The plantation border is fenced with 18 guage g.i. wire at 20 cm height on two lines parallel to the ground, supported on poles and kept in position with the help of guide hooks. The poles are positioned at 3 to 10 m spacing depending upon the terrain of the land. Junction boxes are made with the help of 4 poles, two crushing slabs, the two oval plays and cracker. This may be spaced at 5 to 15 meters apart depending on the landscape boundaries, roads etc. The two fencing lines arriving at the junction boxes from opposite sides are joined on to the oval plays and pulled closer and held in position with the help of a crushing slab hung from a third play kept on the first two plays. Underneath this crushing slab a cracker is kept. When the animal hits the fence, it will cause the first plays to pull apart resulting in the fall of the crushing slab with the cracker on to the second crushing slab kept directly underneath, making the cracker burst. The method has been found very effective in scaring away the animals.

Appendix - I

PESTICIDES AND THEIR DOSAGES USED IN PEST MANAGEMENT IN PALMS

S.No.	Common name	Trade name	Conc % (a.i)	Qty. of trade chemical used in 10 l water
1.	Carbaryl	Sevin 50% WP	0.01 0.10 1.00	2 g 20 g 200 g
2.	Endosulfan	Thiodan 35% EC	0.05 0.10	15 ml 30 ml
3.	Dichlorvos (DDVP)	Nuvan 100% EC	0.02 0.10 0.20	2 ml 10 ml 20 ml
4.	Malathion	Malathion 50% EC	0.05 0.10	10 ml 20 ml
5.	Fenthion	Lebaycid 50% EC	0.10 0.20	20 ml 40 ml
6.	Monocrotophos	Nuvacron 35% EC	0.05	15 ml
7.	Dimethoate	Rogor 35%	0.04 0.05	12 ml 15 ml
8.	Phosphamidon	Dimecron 50% EC	0.02 0.05	4 ml 10 ml
9.	Methyl demeton	Metasystox 30% EC	0.025	8 ml
10.	Dicofol	Kelthane 25% EC	0.05	20 ml
11.	Wettable Sulphur	Microsul 80% WP	0.20	25 g
12.	Chlorpyriphos	Radar 20% EC Classic 20% EC Durmet 20% EC	0.05	25 ml

Appendix - II

LIST OF DELEGATES PARTICIPATED IN THE ENTOMOLOGY GROUP MEETING

1. Dr. K.L. Chadha, Deputy Director General (Hort.), ICAR (Chairman).
2. Dr. M.K. Nair, Director, CPCRI, Kasaragod.
3. Dr. R.N. Pal, Asst. Director General (PC), ICAR, New Delhi.
4. Dr. P. Rethinam, Director, NRC for Oilpalm, Pedavegi, AP.
5. Dr. N.M. Nayar, Emeritus Scientist, CTCRI, Trivandrum.
6. Dr. E.V.V. Bhaskara Rao, Director, NRCC (Cashew), Puttur.
7. Dr. C.C. Abraham, Associate Dean KAU, Thrissur.
8. Dr. P.C. Sundara Babu, Prof. (Entomol) TNAU, Coimbatore.
9. Dr. K.K.N. Nambiar, HD Crop Protection, CPCRI, Kasaragod.
10. Dr. P.K. Koshy, Head of the Station, CPCRI RS, Kayangulam.
11. Dr. K.U.K. Nampoothiri, Scientist-in-charge, CPCRI RC, Palode.
12. Dr.(Ms) N. Saraswathy, Acting Head of the Station, CPCRI RS, Vittal.
13. Dr. C.P.R. Nair, Principal Scientist, CPCRI RS, Kayangulam.
14. Dr. R. Mohan, TNAU, Aliyarnagar, Tamil Nadu.
15. Mrs. A. Sujatha, Ambajipet, Andhra Pradesh.
16. Shri A.L. Narangalkar, KKVP, Rathnagiri.
17. Shri P. Rajan, Senior Scientist, CPCRI RS, Kayangulam.
18. Dr. (Ms) Mariamma Daniel, Senior Scientist, CPCRI RS, Vittal.
19. Dr. B. Padmanabhan, Scientist, CPCRI RS, Vittal.
20. Dr. (Mrs) K.N. Ponnamma, Sr. Scientist, CPCRI RC, Palode.
21. Dr. S.A. Jacob, Sr.Scientist, CPCRI RC, Palode.
22. Shri A.S. Sukumaran, Sr. Scientist, CPCRI, Kasaragod.